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THE KANSAS CITY BRIDGE.*

To this pioneer bridge across the Missouri there attaches an unusual degree of interest, quite enough to warrant the record contained in the handsome quarto volume devoted to the history of its construction.

Across the most fitful as well as the mightiest of our great rivers, the work was by turns imperilled by ice drift or rafts, as well as the heavy push and treacherous scour of its swift current.

How the numberless difficulties were surmounted by engineering expedients, some old and some new, the author describes as fully as can be desired.

We cull from the work so much for the present as relates to the superstructure, reserving for a future article the history of foundations, more especially Pier No. 4.

SUPERSTRUCTURE.

In the early part of August, 1867, letters were sent to a number of prominent American bridge-builders, inviting proposals for the superstructure of the Kansas City Bridge. These letters were accompanied by a set of specifications of general character, which were intended to serve rather as an indication of the quality of bridge wanted, than to contain the precise requirements of a contract. The lengths of the several spans, and the uses for which the bridge was building, were given in these specifications; they also stated that it was designed to build the draw entirely of iron, and the fixed spans of a combination of iron and wood, the latter material being used only to resist compressive strains; the moving loads to be assumed in the calculations were specified, as well as the strains to which the iron might be subjected, and the factor of safety to be used in the wooden parts. The builders, however, were invited to propose any form of truss which they might select, submitting plans of the same if novel, and to suggest such departure from these specifications as might in their judgment seem wise, with the reasons for the change, and a statement of the benefit resulting therefrom. At the same time a set of plans for the fixed spans was prepared by Mr. Tomlinson, under the direction of the chief engineer, which were to be adopted only if, on a fair examination, they were found to be preferable to those submitted by outside parties. It had been intended to prepare plans for the draw as well, but in consequence of the mass of detail which this would involve, and the shortness of the time, it was found impossible to do so.

Nine sets of proposals were received from five different parties, two being on the common Howe truss plan, with both chords of wood; of the other plans, three were adaptations of the Pratt truss, one being entirely of iron, and the remaining

* The Kansas City Bridge. By O. CHANUTE, C.E., and GEORGE MORISON, Assistant Engineer. New York: D. Van Nostrand. 1870.

four were respectively examples of the Post, the double and the single triangular, and the Fisk suspension trusses. On the 30th of October the contract was let to the Keystone Bridge Company, of Pittsburgh, Pa. ; the fixed spans were to be built according to the plans supplied by the chief engineer, the iron in them being paid for by the pound, and the timber by the foot ; the draw was to be built according to the contractors' design, for a fixed sum ; subject, however, to such alterations as might be suggested by the chief engineer, the Company to have the benefit of any saving which might result from such changes, and to pay any extra cost which they might involve. Under this provision certain changes were suggested in the depth of the truss and arrangement of panels, which resulted in a material reduction of the cost. By a subsequent arrangement a pony truss of wrought-iron, made by the contractors from their own designs, was built, in place of the composite structure proposed by the engineer for the shore span of 66 ft.

The general design of the fixed spans is that of a double triangular truss or trellis girder, in which the top chord, posts, and braces are of wood, and the other members of wrought-iron, cast-iron being used in the details and connections. This combination, which has been used as yet only to a limited extent, is believed to overcome the most objectionable features of a wooden bridge, avoiding the wasteful connections which accompany the use of wood in tension, and disposing of the bulk of the perishable material in places where it can easily be protected ; besides this, the character of the butt-joint connections, used to take compression, is such, that worn out parts can be removed and replaced by others without disturbing the remaining parts of the structure ; it is also possible to replace the wooden parts by iron, and thus gradually convert the bridge into an iron structure without the expense of false-works or the intermission of traffic. The braces, which are always open to the air on all sides, are exposed to moisture only during the actual prevalence of a storm, and would therefore be well protected by a thorough coating of paint. The top chord can be covered in, and thereby thoroughly protected from the weather, without perceptibly increasing the wind surface of the bridge. The only danger to which such a bridge can be exposed is that of fire, and if the wood-work be painted throughout with mineral paint, and a watch kept, which is always necessary at Kansas City, men being constantly needed to tend the draw, and collect tolls, this danger is reduced to almost nothing.

The trusses of the 5 fixed spans measure respectively 130, 198, 248, 198, and 176 ft., the difference between these distances and the lengths of spans, given in the preceding chapters, being the allowance made for pedestals, wall-plates, and clearance room. The two shortest of these have straight parallel chords, the depth of truss being 22 ft. ; the same depth is retained at the ends of the larger spans, but in them the upper chord is arched so as to increase the central depth to $\frac{1}{8}$ of the length, the inclination of the braces being kept nearly constant by varying the lengths of the panels. The upper chord of the 130 ft. span is formed of 3 pieces, packed in the usual manner ; in the other spans the chord is of 5 parts, and supplemented at the centre by a sub-chord of 2 parts. The lower chords are of wrought-iron upset links with pin connections, made under the Linville and Piper patent. The end posts and braces bear upon a cast-iron pedestal, which rests on a wall-plate likewise of cast-iron, carefully fitted to the masonry, and well bedded with mortar ; at one end of each span a set of rollers is placed between the pedestal and the wall-plate. In place of the ordinary square ends the braces are cut with 2 end faces, which make an obtuse angle with one another, and the angle blocks are cast to correspond ; this device makes it impossible for a brace to slip upon its bearing, The ties are of square iron, with a welded loop at the lower end, passing around the chord pin, and a screw cut on the upper end, which is previously upset, so as to leave an equivalent area after the cutting of the screw. In the 130 ft. span both the main and counter braces are single, the counters bearing upon cast-iron brackets placed on the sides of the main braces ; the main and counter ties are in pairs running along the sides of the braces. In the other spans the main braces are in pairs, and the counters, which are single, pass between them. In the 176 ft. span both sets of ties are in pairs, the main ties

passing outside the main braces, and the counter ties between the main and counter braces. The arrangement of ties is the same in the central panels of the 198 and 248 ft. spans, but in the panels near the ends there are 4 main ties, 2 passing outside the main braces, and 2 between them and the counter. In all the spans the counter ties are carried only so far as the stiffness requires, but a counter brace is placed in every panel to take a bearing in screwing up the main ties.

The most novel detail of this truss is the top angle block; this is of cast-iron and formed of 3 forms of castings. The respective parts are: *First.* The angle-block proper or brace bearing, which is placed below the chord, and receives the ends of the braces in the central panels of the 4 largest spans; this is cast with extended ends, to form a connection with the sub-chord. *Second.* The keys which pass through the chord in much the same manner as ordinary packing blocks; they are cast hollow, in as many parts as there are spaces between the chord timbers, and with side plates to receive the ends of the timbers whenever a joint is broken. *Third.* The washer plates, which rest on the top of the chord and carry the nuts of the ties; the plates for the main and counter ties are cast separate. The brace-bearings are cast with flanges extending their whole length, which fit into grooves cut in the chords, and bear against the cast-iron keys; the ties pass through the hollow keys, nowhere coming in contact with the wood of the chords. As the ties take hold of the washer-plates above, and the braces rest against the bearing below, both of which bear upon the keys, the strain is distributed, from the first, through the whole section of chord, instead of being thrown entirely upon one edge, as is usual in wooden bridges. The keys also serve to throw the vertical component of the strain in the ties, directly upon the braces, without the intervention of the soft wooden chord.

The lower angle-block, or brace-bearing, is cast in a single piece, having a series of webs on the under side through which the pin passes.

The top laterals are of the pattern commonly used with the Howe truss, except that the bearing of the half struts is taken by small castings placed around the centre of the long strut, instead of being thrown directly upon the wood. The bottom laterals have cross struts and diagonal ties, each strut extending from the foot of a post to the opposite point on the chord-link of the other truss; the ties connect at one side with an eye-plate which fits over the chord-pin, and at the other with bent rods attached by nuts and a casting to the chord-link; each tie is in 2 parts, the adjustment being made with a sleeve nut.

The floor beams, of which there are 2 in each panel, are formed of 2 pieces of pine, each 6 by 15 in., placed side by side and trussed; they are placed above the lower chord and rest upon cast-iron plates with raised centres, by which the weight is distributed equally upon the several links. Owing to the skew of the bridge, which is reduced to 6 ft. 3 in. in the superstructure, the 2 floor beams which come in the same panel on one truss are divided on the other. The floor stringers, running lengthwise with the bridge, are 7 in number, those under the rails being each formed of 2 pieces of 7 by 14 in. pine; on these are laid 2 courses of $1\frac{1}{4}$ in. matched flooring placed diagonally, the planks of the second course crossing those of the first, 3 layers of tarred paper, heavily coated with fresh roofing pitch, being placed between the two; on these is laid a Nicholson pavement 4 in. thick, the whole being covered with sand and pitch in much the usual manner. The rail is of the street rail pattern, weighing 68 lbs. to the yard, and made at the Palo Alto Rolling Mill, at Pottsville, Pa.; it is laid on a longitudinal strip of oak resting on the pine flooring. The floor is given a slight arch, and is drained into gutters on each side, which discharge through cast-iron scuppers, placed at such intervals as to avoid wetting the floor beams.

A foot-walk is placed upon the west side of the bridge, supported by brackets which are bolted to the floor beams; the floor is made of 2 in. plank and a substantial wooden hand-rail is placed on the outside. The top chord is protected from the weather by a covering of pine boards, finished with a narrow overhanging cornice ornamented with brackets. The whole superstructure, including the iron parts, is painted with 3 heavy coats of a mixture of oil and crushed iron ore, manufactured by the Iron-Clad Paint

Company, Cleveland, Ohio; all cracks and weather checks in the timber having been stopped with putty, after putting on the first coat. The wooden keys and all joint-bearings were painted with the same composition before putting the truss together, and the closed covering is covered with a roofing paper made by coating thick brown paper with a coarse variety of this paint.

As the trusses are subject to a double deflection, the expansion of the lower chord under an increase of temperature operating in this way, as well as the strains produced by a load, they are built with a somewhat greater camber than is usually put in railroad bridges; the camber of the 248 ft. span is 8½ in., that of the 198 ft. span 7 in., and those of the 176 and 130 ft. spans, respectively, 5½ and 4½ in. These cambers, however, are materially in excess of any actual deflection.

In proportioning the trusses the central tie rods and the truss rods of the floor beams were allowed to bear a strain of 10,000 pounds to the sq. in. each floor beam being supposed to take the greatest load which the drivers of a locomotive could possibly throw upon it, and no allowance being made for the stiffness of the timber under a transverse strain; the strain in the end ties and chord-links was limited to 12,000 lbs. per sq. in., but no allowance was made for the reduction of strain which the curvature of the upper chord would make in the end panels of the web. This practice of allowing a greater strain per sq. in. on those parts which are fully strained only under a maximum load, than on those which are liable to be strained to the full calculated amount by any heavy locomotive, is believed to have originated with Mr. Albert Fink, and is thought to be a more accurate method of proportioning than the common one, which makes no difference in strain per sq. in. on the different parts under a maximum load. The strain upon the timber of the top chord was limited to 800 lbs. on the sq. in., the braces were proportioned by the well-known formula of Hodgkinson, 7 being the factor of safety adopted. The assumed moving load was 2,240 lbs. per running ft. for the 4 longest spans, and 2,800 lbs. for the 130 ft. span.

The trusses are anchored to the piers by long rods of 1½ in. round iron, which, extending from the top chord, pass over cast-iron struts projecting outwards from the coping, and are fastened by nut and screw through the eye of a 3 in. pin set 15 in. into the masonry. The trusses are further stiffened by corner braces extending from the end posts to a cross stretcher overhead, and the 3 longest spans have sets of similar braces placed at intervals through their length.

The amount of material in the several trusses, including floor beams and stringers, is as follows:

Length of Span.	Timber.	Wrought-Iron.	Cast-Iron.
130	35,739ft. B.M.	44,053 lbs.	27,137 lbs.
176	57,854 "	72,969 "	49,491 "
198	78,277 "	89,449 "	54,119 "
248	101,688 "	147,432 "	70,646 "

To this must be added 194,911 ft. B. M. of pine lumber, 24,167 ft. of oak, 7,200 lbs. of wrought-iron, and 1,700 lbs. of cast-iron, used in the planking, pavement blocks, hand rail, vertical bracing, anchor rods and chord covering, on the fixed spans; this additional amount includes the floor and footway of the 66 ft. span.

The method of manufacture by which the wrought-iron parts were prepared rendered them free from the common danger of defective welds. The chord links were made by upsetting the ends of flat bars of rolled iron till an increase of section somewhat in excess of that required was obtained, and then working down under the hammer and drilling the hole for the pin, leaving them absolutely free from welds. The only weld in the panel ties was that formed in joining the return end of the loop to the long bar; this weld would at most be exposed to but half the strain upon the tie; and even if the weld were absolutely worthless, the tie would have the full strength of a hook around the chord-pin. For these reasons, it was not considered desirable to test every piece of iron with a moderate strain of 20,000 to 25,000 lbs. to the in., as is often done for similar works. Such a strain could at most be expected to reveal the defects of manufacture, which the methods here adopted precluded the possibility of; while the effect of such a

strain, by giving a set to the iron, and imparing its perfect elasticity, would be deleterious rather than otherwise. Samples of the iron were, however, taken and tested to breaking in an hydraulic tester under a slow and long-continued strain, with the following results :

First Test.—Bar, 1½ in. sq., with welded loop at each end, length 5 ft. between centres of loops. Four equal spaces of one foot each were laid out on the central part of the bar. No perceptible extension was noted with a strain of 10,000 lbs. per sq. in., and but little with 20,000 lbs. With a total strain of 130,000 lbs., equal to 57,777 lbs. per sq. in., the length had increased six inches, and the bar yielded by the opening of one of the welds. The four spaces, after the removal of the bar, measured respectively $12\frac{15}{16}$, $12\frac{11}{16}$, $12\frac{3}{4}$ and $13\frac{1}{8}$ in ; the last including a part of the broken weld.

Second Test.—Bar 2 in. sq., 9 ft. long, with loop on one end and nut on the other, extended by strain of 130,000 lbs. 1 in. by 160,000 lbs. 3 in., by 176,000 lbs. 4½ in., by 200,000l bs. 8 in., and by 221,000 lbs. 12 in., when it broke about 18 in. from the nut, showing a fine fibre-like fracture, the strain being 55,250 lbs. to each original inch of section; but the reduced section at the break was only 2.85 sq. in., making the strain somewhat over 77,000 lbs. to the square inch. Five equal spaces of one foot each, laid off on the bar before straining, measured after the break $13\frac{1}{8}$, $13\frac{7}{16}$, $13\frac{9}{16}$, $13\frac{7}{16}$ and $13\frac{1}{2}$ in.

Third Test.—Bar $1\frac{3}{4}$ in. sq., 38 ft. long, and 3.0625 sq. in., under the following strain extended as given below:

	Lbs.	Lbs. to sq. inch.		In.
Total strain.....	26,000.....	8,500..	Extension	$\frac{1}{8}$
" "	52,000.....	17.000..	"	$\frac{17}{64}$
" "	78,000.....	25,500..	"	$\frac{25}{64}$

No perceptible set after strain of 28,000 lbs. on the square inch.

A number of tests were made at the same time of iron of the same quality manufacturing for the Dubuque bridge, with similar results. This iron is of the kind known as Kloman's mixture, manufactured at the Union Iron Mills, Pittsburg, the ties and truss-rods being made of double-rolled, refined iron. The bar broken in the second test was afterwards cut up, and three small pieces were turned out of it, each having a reduced central diameter. These were taken to the Fort Pitt Foundry, and tested in the lever machine belonging to the U. S. Government; two of these tore out of the clutches before breaking, when the strains per square inch were respectively 62,760 lbs. and 63,134 lbs. The last specimen broke under a strain of 84,032 lbs. per sq. in., and showed a beautiful fracture entirely fibrous.

The cast-iron used in the details was a gray iron formed of a mixture of pig, generally adopted by the Keystone Bridge Company.

Specimens were tested by suspending a weight upon a bar two inches by one, and placed upon support four feet apart. The specifications required that this breaking weight should not be less than 2,100 lbs., and in all of the tests it was found to be much in excess of this amount.

The shore span is a riveted trellis girder of wrought-iron 71 ft. long and 8 ft. deep. The chords are of T section, composed of two vertical plates, one horizontal plate and two angle pieces ; in the bottom chord the horizontal plate does not reach to the ends of the span, and the other parts are continuous for the whole length. The braces are each formed of two pieces of T iron placed back to back, and enclosing the ties, which are single bars of flat iron ; both ties and braces are riveted between the vertical chord plates. The laterals are of wrought-iron, and the trusses are stiffened by short braces of T iron connecting the floor with the web. The end posts are enclosed in light ornamental castings. The floor beams are of pine, 6 in. by 18, without trussing, placed 2 ft, between centres; on this is laid a floor similar to that on the other fixed spans. The amount of material in this span, exclusive of pavement and hand rail, is as follows : Lumber, 7,684 ft. B. M.; wrought-iron, 32,165 lbs.; cast-iron, 4,328 lbs.

The draw measures 361 ft. and 3 in. over all; it is a Pratt truss of similar plan to the large draws erected by the Keystone Bridge Company at Cleveland, Dubuque, and other points. The skew is taken out of the truss by making the end panels of unequal lengths, the difference being 5 ft. 6 in. The upper and lower chords are of like pattern, formed of two I beams and two channel bars 8 in. deep,

placed side by side and united by a plate riveted to their upper flanges. The posts are of wrought-iron, of the Linville pattern. The ties are round, with both ends upset for screws; the main ties are in pairs, and the counters single, passing through the posts. The washer plates upon which bear the nuts of the ties are of cast-iron, except the top centre, which is forged. The floor beams are 10-in. rolled I beams, and rest on the top of the lower chord. The floor is of 2-in. oak plank laid on the oak track stringers, and pine floor joists. There is no separate footway on the draw. The turn-table is formed of an external drum 30 ft. in diameter, and a central shell of cast-iron, hung by ten bolts on one of Sellers' patent pivots; the drum and shell are connected by a pair of plate girders under the centre posts, and a set of radial rods. The bolts are adjusted so as to throw almost the entire weight on the centre, the drum serving only as a guide and balancer. The draw is easily opened by four men, with levers attached to two pinions on the drum, in two minutes, but as a precaution against wind and other dangers, it is to be fitted with a steam-engine. The latch is worked from the centre by a hand-lever; a bearing is secured by wedges which are driven under the four end-posts, the four being worked by a single central lever. The amount of material in the draw, including both trusses and turn-table, is as follows: Timber (in floor), 26,025 ft. B. M.; wrought-iron, 495,575 lbs.; cast-iron, 122,041 lbs.

In proportioning the draw, it was supposed to carry the whole dead load on the central bearing when swung, and each arm was supposed to carry its share of the dead load, and a moving load of one ton to the foot when closed, no allowance being made for the continuity of the chords. Though this has been the method by which most of the large iron draws lately built have been proportioned, the engineers were convinced that it is a method of computation which gives very erroneous results, showing the central strains, especially in the web, to be much less than they really are, with corresponding excesses in other parts; a set of calculations believed to be based on a more correct hypothesis will be found in a subsequent chapter. The distribution of strain is regulated by the proportion of the total weight thrown upon the end piers, and is therefore largely dependent on the form of latch used. The wedges under the end posts have but a small lifting power, as is fully proved by the action of the draw under a passing load, a heavy freight train, covering one arm only, causing the further end to rise from its bearings $\frac{7}{8}$ of an inch. A set of hydraulic jacks are to be substituted for the wedge plates, the jacks being placed within the hollow end-posts and worked from the turn-table by pumps driven by the steam-engine; it is thought that under this arrangement a sufficient lifting power can be obtained to make the proportioning of the draw sufficiently correct to prevent distortion. * * *

The greatest difficulties occurred in the case of the span between Piers 3 and 4, where the strength of the current and the depth of the water, especially near Pier No. 3, would have carried away any common false-works in a very few hours. The distance between the caisson around Pier No. 3 and the false-works at No. 4 was divided into four nearly equal spaces. Between the first and second of these spaces, a cluster of eight piles in two rows 8 ft. apart was driven in 35 ft. of water, the piles being kept from washing out by guying them with lines as fast as driven; a crib of round timber was then built, enclosing the piles, which on being sunk by filling it with stones, shou'd at once retard the wash and bind the piles together. A precisely similar arrangement was adopted between the second and third spaces. This work was begun on the 10th of March; on the 14th the weather became very cold, and the ice began to run in large quantities; the numerous obstructions of the false-works impeded the flow of ice, and in the forenoon of the 16th it jammed at the bridge site and the river became closed. The weather had already begun to moderate, and in the afternoon of the same day the ice moved out; it was very weak, but the cakes had packed together, forming large thick fields, which, however, were too soft to bear the weight of a man. The sixteen piles of the two clusters had been driven, a crib had been built about the first cluster, though not sunk, and carpenters were at work upon the second crib, when the ice began to move across the whole width of the river at once; it tore out all

of the sixteen piles, taking the cribs with them, and carried along with it the pile-driver, barges and men. The boats moved but slowly, being frequently retarded by ice jams, and while still opposite the town they were overtaken by the steamboat and secured, having suffered no material damage; but no trace of piles or crib-work remained, and two months later one of the cribs was observed 40 miles down the river, with a pile still remaining in it. This gorge was accompanied by a considerable scour, the water at the site of the second set of piles having been deepened about 12 ft.

The piles were at once replaced, and the cribs built, sunk, and protected by additional riprap; the piles were then capped and surmounted by trestle piers, which were planked on the sides and provided with timber starlings, 8 or 10 ft. high, as a protection against drift. * *

The draw span was raised on false-works extending from the pivot pier to the upper and lower rests. As the small amount of sand above the rock precluded the driving of piles, these works were built on cribs, two of which, loaded with stone, were placed between the pier and each rest. These cribs were originally intended to serve as the foundation of a permanent draw protection; they were built in the winter of 1868–9; were made 30 ft. square, and divided by four cross-walls into nine compartments. The deadening effect of the upper rest and pier on the current, had so checked the scour that the cribs did not settle to the rock, and as their bearing was not thought to be firm enough to carry a permanent structure, they were built up above ordinary high-water, and a wooden truss, strong enough to sustain itself if the cribs settled, and which should serve as false-works for raising the draw, was built upon them.

As soon as Pier No. 2 had been completed, the pivot was placed upon it, and the turn-table put together; the chords were then spread out and riveted, and the bridge trusses made self-sustaining at the earliest possible moment, the whole structure being raised in about six weeks. The cribs settled slightly under the weight of iron, but not enough to give trouble, the subsidence being remedied by additional blocking. Since then the upper cribs have not settled materially, and are probably on their permanent bearing; but the night after the weight of the truss had been taken off the false-works, a rise in the river scoured around the two lower cribs, causing them to settle away from the truss; under the continued scour of the summer flood they continued to settle, tilting from side to side, and finally, when the flood was at its height, they tipped over and rolled away; the false-work truss remains standing, and no harm was done to the works.

On the occasion of the public opening on the 3d of July, the bridge was tested in the presence of a number of engineers invited to examine it, with the following results. We give the results of the long span and draw only:

248 FOOT SPAN.

Fully loaded	233 Tons.
North quarter Deflection	$5\frac{1}{2}$ Inch.
Centre "	$6\frac{5}{32}$ "
South quarter "	$4\frac{13}{32}$ "
Permanent Set	$\frac{5}{32}$ "
Elongation of Bottom Chord	$\frac{3}{8}$ "

DRAW SPAN.

North Arm Loaded	170 Tons.
North quarter Deflection	$5\frac{3}{32}$ Inch.
Centre "	$3\frac{1}{32}$ "
South quarter "	$1\frac{5}{32}$ "
Centre of South Arm rose	$4\frac{19}{32}$ "
Both Arms loaded	313 Tons.
Centre Deflection, North Arm	$1\frac{9}{32}$ Inch.
Permanent Set " "	$\frac{1}{8}$ "
North quarter Deflection, South Arm	$\frac{15}{32}$ "
Centre Deflection, South Arm	$4\frac{7}{32}$ "
South quarter Deflection, South Arm	$\frac{9}{32}$ "
Permanent Set	$\frac{3}{8}$ "

It is to be noted that these tests were made before the bridge had been screwed up under a load, and while the bearings were not perfectly close; they consequently show greater deflection than a subsequent testing would indicate.

THE Hoosac Tunnel, it is reported, is now progressing at the rate of 10 ft. a day—4 ft. from the west end, and 6 ft. from the east end. The central shaft is complete; its depth to the floor of the tunnel is 1,030 ft. Work at the new headings is already begun. The tunnel has been excavated 11,765 ft. at both portals, that is, 6,946 ft. at east side, and 4,819 ft. on the west side.

ON THE MANUFACTURE OF IRON AND STEEL BY DIRECT METHODS.*

Although by far the greater part of the wrought iron and steel now used in the arts is made from cast iron produced in the blast-furnace, the history of iron-making shows us that in early times malleable iron, and even steel, were obtained directly from certain ores, without the previous production of cast iron, and without fusion. The manufacture and use of the latter, in fact, date only from a comparatively recent period. The natives of India, Burmah, Borneo, Madagascar, and some parts of Africa, practise the direct conversion of iron ores to the metallic state in small furnaces. In certain districts of India the amount of malleable iron thus produced is very considerable, and much of it is manufactured into steel; but the furnaces used are small in size, and produce not more than from 20 to 40 lbs. of iron in a day, with the labor of three or four men, and with a great waste of ore and of charcoal. The rich native ores, coarsely pulverized, or the grains of iron ore obtained by washing the sands of certain districts, are heated with charcoal in small furnaces, until they are reduced and yield masses of malleable metal. Somewhat similar methods of making malleable iron have long been known in various countries of Europe, where, under improved forms, they are still followed, and have thence been brought to America. Of these furnaces for the direct conversion of ores into malleable iron, the five known in Europe are the Corsican and Catalan forges, the German bloomary forge, the Osmund furnace, and the German Stuckofen or high-bloomary furnace, which latter had high walls, and approached in form to the modern blast-furnace, of which it seems to have been the immediate precursor. For a detailed description of these various furnaces, and the mode of working them, the reader is referred to Dr. Percy's learned work on the metallurgy of iron and steel. Inasmuch, however, as furnaces related to the German bloomary are still largely used on this continent, and promise to become of considerable importance to Canada, it will be well to describe briefly some points in the history of these various European furnaces.

Of these, the best known is the Catalan furnace or forge, so called from the province of Catalonia, in Spain, where it was formerly much used, as well as in the neighboring parts of France. The department of Ariège, in 1840, had in operation 49 of these furnaces, producing 5,800 tons of metal, of which 215 tons were a crude kind of steel, the remainder being malleable iron. The process has there, however, since probably fallen into disuse. Similar forges continue to be employed on the Italian coast, and, in 1850, there were 40 of them in operation in the province of Genoa, where they were used for the treatment of specular iron ore brought from the island of Elba. In the French Pyrenees, however (department of Ariège), the ore generally used in these furnaces is a hydrous brown oxide, holding from 40 to 50 per cent. of iron, and approaching in its character to the bog ores of the province of Quebec.

The Catalan forge consists of a rectangular hearth, constructed chiefly of heavy iron plates, which, in the largest size, is about 40 by 32 in., and from 24 to 27 in. deep, or from 14 to 15 in. below the twyer. In some districts, however, furnaces of not more than one-half these dimensions are built. The pressure of the blast employed does not exceed $1\frac{1}{2}$ or $1\frac{3}{4}$ in. of mercury, and the twyer is directed downwards, at an angle of 30 or 40 deg. The wall facing the twyer, slopes outward towards the top, and in working, the greater part of the charge of ore is heaped against it, and occupies from one-third to one-half of the cavity of the furnace, the remaining space being filled with ignited charcoal. The ore is previously broken so that the large lumps are not more than 2 in. in diameter, while from one-third to one-half of the material will pass through a screen, the bars of which are four-tenths of an in. apart. This finer ore is thrown on the surface of the fire, from time to time, during the operation, which is conducted with many precautions as to regulating the blast, stirring, supplying the fine ore and coal.

* Extract from the Report of Dr. T. Sterry Hunt, Chemist and Mineralogist of the Canadian Geological Survey.

At the end of 6 hours, in the ordinary routine, there is withdrawn from the bottom of the furnace an agglomerated mass of reduced but unmelted iron, which is then forged into blooms or bars. The operation, lasting 6 hours, consumes, in one of the larger sized forges, about 9½ cwt. of ore and 10½ cwt. of charcoal, and yields 3 cwt. of bar iron. According to another calculation, there are required for the production of 100 lbs. of iron, 340 lbs. of charcoal and 312 lbs. of an ore containing from 45 to 48 per cent. of iron. Of this about seven-tenths are obtained in the metallic state, the remaining three-tenths passing into the slag. 100 lbs. of ore yield 31 lbs. of bar iron, and 41 lbs. of slags, which are dark-colored basic silicates, very rich in oxide of iron.

The Corsican forge is a more primitive form of furnace than the Catalan, and without interest, except so far as it belongs to the history of iron-working. It is said to have consumed more than 800 lbs. of charcoal for the production of 100 lbs. of iron. Some few of these forges were still in operation in Corsica forty years since.

Another form of furnace, described by Dr. Percy under the name of the Osmund furnace, was used during the last century in Norway and Sweden. It was a rude hearth, with walls around it, and an opening in one of the sides near the tap-hole, which was built up with stones, and taken down when it was required to extract the loup or mass of reduced iron. This furnace was not capable of yielding more than 1½ tons of iron in a week, but is still used in Finland; and it is mentioned as a curious fact, that certain bog ores which contain so much phosphorus as to yield but a poor and hot-short iron by treatment in the blast-furnace, and subsequent decarburation, afford a good malleable iron when reduced by the direct method, in the Osmund furnace; a result which appears to be due to the fact that the phosphorus, which is reduced and passes into the iron, in the blast-furnace, escapes reduction at the lower temperature of the Osmund furnace.

An improvement in the Catalan forge has been introduced in the province of Genoa, in northern Italy, and consists in the utilization of the waste heat, which is made to roast, and subsequently partially to reduce, the ore before treating it in the forge. For this purpose a flat-bedded reverberatory furnace, so constructed as to receive, at one end, the flame from the forge, was provided at the other end with a charging-door, within and above which was a vertical chamber, communicating with the chimney, and having a side-door, and a grating at the bottom. Upon this grating, the ore, a specular oxide containing 68 per cent. of iron, was laid, and exposed to the heat, which roasted it, expelling a small portion of sulphur. After being thus heated for some time, it was withdrawn and thrown into water, by which process it was rendered friable. Being then broken into small lumps and coarse powder, it was spread out evenly on a layer of broken charcoal, with which the bottom of the reverberatory hearth had previously been covered, and was here exposed to the heating effect of the waste flame from the forge, during the whole time of working a charge in the latter. In this operation the bed of charcoal was consumed, and the ore lost 10 or 12 per cent. of its weight, being partially deoxidized. Some scraps of cast iron or wrought iron were then added to the half-reduced ore, and the whole mass, by means of a rabble introduced through the charging-door, was pushed forward into the forge-hearth. In this way 5 heats, instead of 4, could be worked off in 24 hours, with great economy in charcoal, improvement in the quality of iron, and a somewhat greater yield. Separate furnaces were also constructed in connection with these works, for reheating the iron to be drawn out into blooms, and the waste heat from these was also employed in heating reverberatories, as above explained.

One of the Catalan forges, with these improvements, yields in a week of 6 days, 30 heats of iron, with an average consumption, for each heat, of 95.30 kilogrammes of ore in lumps, 63.50 of ore in powder, 31.75 of wrought-iron scrap, and 254.00 of charcoal, with a yield of 143.00 kilogrammes of bar iron. This is equal to 1,575 lbs. of iron in 24 hours, with a consumption of 2,794 lbs. of charcoal. It is, however, to be noticed that about 22 per cent. of this product, or 349 lbs., was added in the condition of wrought-iron scrap, whose re-working would consume comparatively little charcoal. Making a liberal allowance for this, we may fairly consider the work of the furnace as nearly

equal to the production, from the ore, of 1,400 lbs. of iron, which is at the rate of 50 lbs. of iron for 100 lbs. of charcoal consumed, and is about the result obtained with the American bloomaries, to be noticed farther on; while the proportion obtained with the unimproved Catalan forge, described above, is only at the rate of 30 lbs. of iron to 100 lbs. of charcoal.

Mention has already been made of the German high-bloomary furnace, or Stuckofen, which is of no particular interest in this connection, and is not to be confounded with another furnace known simply as the German bloomary. This was formerly used in Silesia and the Palatinate, and is described at some length in the classic work of Karsten, written a little more than half a century since (1816), but is dismissed with a few words in Bruno Kerl's treatise on metallurgy, published in 1864 ("Huttenkunde," iii., 427), from which its use would seem to be nearly or quite abandoned in Germany. According to Karsten, the German bloomary consisted of an iron pot, or a box of iron plates, in either case lined with refractory bricks, and having an internal diameter of from 14 to 21 in., and the same depth, the dimensions varying with the fusibility of the ore, the force of the blast and the quality of the coal. The twyer was horizontal; the furnace having been filled and heaped up with burning charcoal, the ore was thrown upon the fire by shovelfuls at a time; this process was continued, the supply of fuel being renewed, until a loup of sufficient size had been formed at the bottom of the hearth, as already described in the Catalan method. When the blast is too intense, or the coal very dense, it may happen that the reduced iron becomes carburetted to such an extent as to produce steel-like iron, or even molten cast-iron, instead of a loup of soft malleable iron. A similar state of things sometimes occurs in the Catalan forge, and is occasionally taken advantage of to obtain an imperfect kind of steel.

From the above description it will be seen that the method by the German bloomary differs from that by the Catalan forge, in the fact that, in the latter, the greater part of the charge of ore is placed, at the commencement of the operation, in a coarsely broken state, on the sloping wall of the furnace, opposite to the twyer, while the remaining portion is subsequently projected, in a more finely divided condition, upon the surface of the fire. In the German method, on the contrary, the whole of the ore is reduced to this finer condition, and is added by small portions, a plan which dispenses with the charging of the furnace after each operation, as in the Catalan method, and permits of a continuous working, interrupted only by the withdrawing of the loups from time to time. The German bloomary, in an improved form, is extensively used for the reduction of iron ores in the United States, where it is known by the name of the bloomary fire, the Jersey forge, or the Champlain forge, and is also frequently called the Catalan forge, from which, as has already been shown, it is distinct in form, and still more distinct in the manner in which it is worked. Before proceeding to describe in detail the American bloomary fire, it will be well to notice some of the advantages of the direct methods of extracting iron from its ores, and to point out the conditions under which they may be used with advantage.

Karsten remarks that the iron ore obtained by a direct process is often of a superior quality, for the reason that the separation of the foreign matters of the ore is effected by a kind of liquation, rather than by complete fusion; and, moreover, that certain impurities, which would be reduced and unite with the iron at higher temperatures, are carried off by the slags, in an unreduced state, at the lower heat of the open forge. A striking illustration of that has been given above, in speaking of the Osmund furnace, and its use in Finland. For these reasons Karsten was of the opinion that in some regions, and with certain ores, the direct process was, perhaps, more advantageous than the use of the blast-furnace combined with the finery-hearth. This, however, was half a century since, and, in the meantime, great improvements have been made in the manufacture of cast-iron, as well as in puddling or otherwise treating the pig-metal. In view of all these facts, and of the greater facilities for transportation at the present day, Dr. Percy observes (in 1864), "that there can only be comparatively few localities in Europe where these (Catalan) forges can be conducted with profit. In mountainous regions abounding in rich iron ores and

wood suitable for charcoal, and still inaccessible to railways, the Catalan process may hold its ground, but certainly not in localities where it is unprotected by high rates of carriage, or other circumstances, from competition with iron smelted and manufactured by modern processes. Its advantages are that the outlay and floating capital required for a forge are inconsiderable, and the consumption of charcoal is comparatively small."—(Percy, "Metallurgy of Iron and Steel," page 311.)

The German bloomary process was probably introduced into North America early in the last century. Among the forges in operation in New Jersey and Pennsylvania in 1856, Lesley, in his "Iron Manufacturers' Guide," mentions one as having been established in 1733, and another in 1725. These were, perhaps, bloomaries for the conversion of pig-iron by the Walloon method, which was used in this region at an early date; but it is evident, from facts cited already, that the treatment of pulverized iron ores in the German bloomary fire was already practised in Connecticut as early as 1761. It was, probably, the coming of German immigrants which led to the use of the German rather than the Catalan forge, which, so far as I can learn, is unknown, at least, in the northern and eastern parts of the United States. Various improvements have been, from time to time, made in the construction of the furnaces, the most important of which has been the introduction of the hot blast. Favored by supplies of rich ores, and protected, to a certain extent, from foreign competition, by duties on imported iron, the manufacture of iron by this method has been widely extended over the United States, and has assumed considerable importance. In the districts where it was first introduced, including northern New Jersey and the adjacent portions of New York and Pennsylvania. the bloomary process is falling into disuse, since wood has become scarce, and extensive workings of coal in the vicinity, with the great facilities for transportation, have rendered it more profitable to treat the ores in the blast-furnace than in the bloomary fire. In northern New York, on the contrary, the use of the direct process appears to have considerably extended during the past few years.

The works for producing iron directly from the ores, by the present method, are known in the United States as forges or bloomaries, and sometimes consist of 20 forge-fires or furnaces, but in many cases of not more than 2 or 3. According to the report prepared by Mr. Charles E. Smith, for the "Iron Manufacturer's Guide" (page 760), and published by authority of the American Iron Association, there were, in the year 1856, produced directly from the ore, 28,633 tons of malleable iron, from 203 forge-fires. Of these, 42 were in New-York, 48 in New Jersey, 36 in North Carolina, 14 in Alabama, and 50 in Tennessee. There were besides, at that time 35 abandoned fires, of which not less than 29 were in New Jersey. The average production from each forge-fire was thus 141 tons. Since that time I have no means of knowing the condition of this manufacture in the south and west. In New Jersey, for reasons already given, the direct method is almost abandoned, while in northern New York, on the contrary, it has greatly increased. Instead of the 42 fires reported in 1856, there were, in 1867, according to the "Iron and Steel Association Bulletin," 136 fires in activity in Essex and Clinton counties, the principal seats of this industry. The aggregate product of these forges was supposed by a competent authority, in 1868, to be nearly 40,000 tons of malleable iron, a large portion of which is consumed at Pittsburgh for the manufacture of steel by cementation, a process for which this iron is eminently fitted, and for which that reduced from the ore of the Palmer ore-bed, near Keeseville, is especially prized. Two establishments in the neighborhood work the ore of this deposit; one, that of Messrs. Rogers, of Ausable Forks, had 21 fires, and the other, that of the Peru Company, of Clintonville, 18 fires, in 1868.

The direct method of reduction cannot be applied to poor ores, which, to yield good results in the German or Catalan forge, should not contain much less than 50 per cent. of iron, while much richer ores are to be preferred. Some of the iron ores of North America consist of an aggregate of crystalline grains of magnetic oxide, mingled with so large a proportion of calcareous or silicious matter as render them unfit for the bloomary fire, without purification. This is generally effected by crushing and washing, after a previous partial calcination, and leaves the ore in

a coarsely granular state, which would not be adapted to the Catalan, although well suited to the German or American method. This condition of things is illustrated by the ore of the famous Palmer bed, just mentioned. I was informed at the works of Messrs. Rogers, that from 4 to 5 tons of the average crude ore were required to make a ton of blooms. The ore, as raised from the mine, is chiefly magnetite, with grains of white quartz, and, in some portions, of flesh-red feldspar. It is slightly roasted, to render it friable, then stamped and passed through screens with openings of about $\frac{1}{8}$ of an in., and purified by washing. Two tons of the washed ore were required to make a ton of blooms. I took what seemed an average sample of the crushed ore from the stamps, and having further reduced it so that it would pass through the meshes of a sieve having 16 holes to the linear in., carefully separated the magnetic from the non-magnetic part, which contained a proportion of grains of specular iron ore, but was chiefly quartz. The magnetic portion equalled 45 per cent. of the whole. A sample of the dressed ore, such as supplied to the bloomaries, was treated in the same manner, by further crushing, and separation by the magnet, and contained 64 per cent. of magnetic ore; the non-magnetic portion, besides silicious matters, holding a considerable proportion of grains of specular iron, which would probably raise the amount of oxide of iron in this sample of the water-dressed ore to about 85 per cent., or a little over 60 per cent. of metallic iron. In other districts of northern New York, as in the vicinity of Port Henry, the crude ores are richer than those just mentioned, and often con tain very little extraneous matter, so that the operation of washing may sometimes be dispensed with. At the new Russia forge, in Moriah, the ore, which is mingled with a little quartz, is roasted in piles, with wood, during two or three days, then crushed and treated as above described. Two tons of the crude ore yield $1\frac{1}{2}$ of dressed ore, which is calculated to give 1 ton of blooms. The washing process removes not only the foreign matters, but a portion of fine ore, which is lost, and may be seen accumulated in the vicinity of the washing-tables. The bloomers, as the iron-makers are called, object to this fine ore, as being unfit for use; but it will be seen further on that this prejudice is without foundation, and that the finer grains can be used with advantage, though they are now rejected, and considerable loss is thereby incurred.

The magnetic ores of Lake Champlain are exported to Vermont, where, for several years, a few bloomaries have been supplied with iron ore from the west side of the lake. Three forge-fires were, in 1868, in operation at Salisbury, and 3 at East Middlebury, Vermont, 5 miles from the Middlebury station on the Rutland and Burlington Railway. The ore for this purpose is brought by water from Port Henry or Port Kent to Burlington, and thence by rail to Middlebury station. This is brought partly in lumps, which are crushed and washed at the forge, and partly dressed to a high degree of purity, and ready for use.

Overman is, so far as I am aware, the only writer who has given any account of the American bloomary process. In his "Treatise on Metallurgy" (sixth edition, 1868, page 541), will be found a description, accompanied by figures. My own observation, as here given, have enabled me to verify the general correctness and trustworthiness of Overman's statements with regard to this subject.

The bloomary hearths or furnaces in different localities exhibit some little variations in size and in the details of their arrangements. The size of the hearth varies from 27 by 30 to 28 by 32 in., and the height, from 20 to 25 in. above the twyer, and from 8 to 14 in. below. The sides are made of heavy cast-iron plate, and the bottom, although often of beaten earth or cinders, is, in the best constructed hearths, also of iron, made hollow, and kept cool by a current of water, which is made to circulate through it. In the East Middlebury forges this bottom-plate is 4 in. thick, and has within it a hollow space of 2 in. The side-plates, which slope gently inwards, in descending, and rest on ledges on the bottom-plate, are $1\frac{1}{4}$ in. thick. A water-box, measuring 12 by 8 in., is let into the twyer-plate, and a stream of cold water circulates through this box, and through the bottom-plate, as well as around the twyer. The length of the hearth, from the twyer-plate to that opposite, is $24\frac{1}{2}$ in, and the breadth from front to rear is 29 in. The twyer enters 12 in. above the bottom, and is in-

clined downwards at such an angle that the blast would strike the middle of the hearth. The opening of the twyer has the form of a segment of a circle, and is 1 in. high by $1\frac{3}{4}$ in. wide. In front of the furnace, at 16 in. from the bottom, is placed a flat-iron hearth, 18 in. wide. The side-plate beneath it is provided with a tap-hole, through which the melted slag or cinder may be drawn off, from time to time. The iron plates used in the construction of these furnaces last for 2 years. In the furnaces used at the New Russia works in Moriah, already mentioned, the iron bottom-plate is not made use of, the bed consisting of beaten-down earth or ashes. These furnaces have a depth of 24 in., and measure 20 by 32 in. at the top, but are somewhat smaller toward the bottom; the twyer, in these, enters one of the narrower sides of the rectangle. While these are somewhat smaller than the forges at East Middlebury, those lately constructed at Moisie are somewhat larger, measuring 30 by 32 in., the bottom-plate being 14 in. below the twyer, which is placed nearly horizontal, but of the same size as that described above.

The blast employed in the American bloomaries has a pressure of from $1\frac{1}{2}$ to $1\frac{3}{4}$ lbs., and is heated by passing through a series of cast-iron tubes, placed in an upper chamber, above the furnace. These are in the form of inverted siphons, each limb being about 7 ft. in length, their exterior diameter 7, and their interior diameter 5 in. At the East Middlebury forges the air is made to pass successively through 3 such tubes, heated to dull redness, and attains a temperature estimated at from 550 deg. to 600 deg. Fahrenheit. The use of the hot blast hastens the operation, and enables the workmen to produce a larger quantity of iron in a given time, than with the cold blast, while, at the same time, it effects a considerable saving in fuel. It is said that where 240 bushels of charcoal will produce a ton of iron with the hot blast, 300 bushels of the same coal would be consumed if the cold blast were used. The quality of the metal is supposed to be deteriorated if too hot a blast is used. With judicious management, however, the use of the hot blast offers great advantages over the cold blast, and has been very generally adopted in the American bloomaries.

The working of these furnaces is conducted in the following manner: The fire being kept active, and the furnace heaped with coal, the coarsely pulverized ore is scattered, at short intervals, upon the top of the burning fuel, and in its passage downwards is reduced to the metallic state, but reaches the bottom without being melted, and there accumulates, the grains agglomerating into an irregular mass or loup, as it is termed, while the earthy matters form a liquid slag or cinder, which lies around and above it, and is drawn off from time to time through the openings in the front plate. At the end of two or three hours, or when a sufficiently large loup is formed, this is lifted by means of a bar, from the bottom, brought before the twyer for a few minutes, to give it a greater heat, and then carried to the hammer, where it is wrought into a bloom; the bloomary fire itself being generally used for re-heating. This operation concluded, the addition of ore to the fire is resumed, and the production of iron is thus kept up, with but little interruption. In this way a skilled workman will, with a large sized furnace, bring out a loup of 300 lbs. every 3 hours, thus making the produce of the day of 24 hours, 2,400 lbs. of blooms; in some cases, it is said, 1,500 lbs., and even more, are produced by 12 hours working.

In this connection may be mentioned an arrangement, described and figured by Overman, in which the waste heat from the forge (or rather from two forges united) passes into an oven or stove, placed at a level above the bloomary-fire, and there serves to re-heat the blooms, when it is required to draw them out into bars. A set of small blast-pipes, placed just above the forge, serves to heat a portion of air, which is led into the oven, and there burns any escaping carbonic oxide gas. The air and gases from the re-heating oven are afterwards employed to heat the blast for the bloomary hearth, in the usual manner. I have not seen this arrangement in operation.

The following observations will serve to give some notions of the working of the bloomary process in the United States. At the Ausable works, as already stated, the somewhat lean ores are dressed so as to yield about 50 per cent. of iron, 2 tons of ore being required for 1 ton of blooms,

while at the New Russia forges, in Moriah, near Port Henry, where a nearly pure magnetite is employed, 3 tons of the dressed ore are stated to yield 2 tons of blooms. When it is considered that perfectly pure magnetite contains only 72.0 per cent. of iron, this proportion of 66.6 per cent., said to be obtained, shows a great economy in working. These figures, furnished me by the proprietor of the forges, Mr. Putnam, were afterwards confirmed by Mr. Pearson, the director of those at East Middlebury, where the very rich ores from the same region are treated. The dimensions and construction of the New Russia forges have already been given. The pressure of blast employed was from $1\frac{1}{2}$ to $1\frac{3}{4}$ lbs., and the average produce of iron for each fire, 2,400 lbs. of bloom-iron in 24 hours; the amount of charcoal consumed being from 250 to 300 bushels to the ton of blooms produced, and the weight of the charcoal from 16 to 18 lbs. to the bushel.

At East Middlebury, where, as just stated, the conditions are very similar, the estimated consumption of charcoal was 270 bushels to the ton of blooms—a result which is the mean of the figures obtained at the New Russia forges. Some of the ores here used contain a little phosphate of lime, and it was observed that when too hot a blast was used, although the production of metal was rapid, the iron from these ores was hot-short, while with the cold blast, formerly employed, the iron, although produced more slowly, was never hot-short. The force of the blast at these forges was equal to $1\frac{3}{4}$ lbs., and even 2 lbs. to the in. Mr. Pearson, the director of the East Middlebury forges, made, in the autumn of 1867, experiments on several tons of the iron sands from Seven Islands, and succeeded in obtaining from them about three-eighths of their weight of good iron. He, however, found it necessary, in order to treat these fine sands, to reduce very much the force of the blast, an experience which has been confirmed by the practice at Moisie. It appears to be from ignorance of this fact that the bloomers of New York had always rejected the fine sandy ore separated during the process of washing, as being unsuited for treatment in the bloomary fire.

At Moisie, although eight forges have been constructed, but four of them were in operation at the time of my visit in August, 1868, and the same number, I am informed, in October last, two of the furnaces not having yet been completed. A reverberatory furnace has, since my visit, been constructed, in which it is proposed to re-heat the loups for the second hammering, instead of returning them, as in most cases is done, to the forge-fire for that purpose. The opening of the twyers used measured 1 in. by $1\frac{7}{8}$; they were inclined downwards at a very small angle, it having been found by experience that the considerable inclination which is used with the coarser ores cannot be advantageously employed with the fine sands. In like manner, as remarked above, it has been necessary to reduce the force of the blast, to from $\frac{7}{8}$ to $1\frac{1}{4}$ lbs., the average working-pressure being about 1 lb. to the in. According to the latest accounts, there were, in October, 4 hearths in regular operation, requiring 4 bloomers, 1 assistant to furnish coal, etc., and 1 hammerer, being 6 men in all for each shift of 12 hours. Each hearth furnished 8 loups daily, and the aggregate yield of iron was estimated at 3 tons, or $\frac{3}{4}$ of a ton for each earth every 24 hours. The consumption of charcoal was 1,400 bushels daily, being at the rate of 466 bushels to the ton of blooms, or 350 bushels to each fire. This charcoal is chiefly produced from spruce and fir, with some admixture of birch, the wood being mostly small, and the weight of the coal is stated to be 15 lbs. to the bushel. This gives a consumption of 6,990 lbs. of charcoal for the production of 2,240 lbs. of blooms, being at the rate of 3.12 lbs. of charcoal for the pound of iron. If we compare this result with the figures given above, for those forges which treat nearly pure magnetic iron ores, we find that to produce a ton of blooms there are consumed, at East Middlebury, 270 bushels, and at New Russia from 250 to 300 bushels of charcoal, weighing from 16 to 18 lbs. to the bushel. If we assume, in both cases, the greater weight, of 18 lbs. to the bushel, we have for 250 bushels, 4,500 lbs., and for 300 bushels, 5,400 lbs. of charcoal, the former corresponding to 2.01 lbs., and the latter to 2.41 lbs. of charcoal to the lb. of iron; or, taking the mean of the two, 2.21 lbs., as compared with the 3.12 lbs. said to be consumed at the Moisie works.

If now, we consider the relative sizes of

the different bloomary hearths, we find them to be as follows :—

New Russia.....	20 × 32 in.	= 6.400 sq. in.
East Middlebury..	24 × 29 "	= 6,960 "
Moisie.....	30 × 32 "	= 9,600 "

The area of the Moisie hearths is, then, in round numbers, 1½ times that of the others, and, with an equally powerful blast, they should consume ½ more charcoal. This increased size is, however, counterbalanced by the feebler blast, and we find that each fire at Moisie consumes, in 24 hours, 350 bushels of charcoal, equal to 5,250 lbs., which, from the calculations already given for the New Russia forges, should produce, with an ore such as there treated, 2,375 lbs. of iron. In fact the Moisie forges, according to the data before us, with an area ½ greater, consume daily the same weight of charcoal as those of New Russia, and produce only ⅔ as much iron.

I have recently been informed that, with careful management, it has lately been found possible so far to reduce the consumption of fuel at Moisie, that a ton of blooms can be made with 350 bushels of properly prepared charcoal. The consumption of ore, which formerly amounted to 3 tons or more for a ton of blooms, is also said to have been considerably reduced, the daily production of iron from each hearth, however, remaining the same as before.

The cause of this small production of iron, as compared with the area of the furnace, and with the consumption of fuel, is not, in my opinion, to be found either in the reduced force of the blast or in the mechanical condition of the ore. A great heat is not required for the reduction of the oxide of iron to the metallic state, and other things being equal, the finer its subdivision, provided it be not dissipated by the blast, the more rapid and more complete should be its conversion to the condition of metal, by the action of the reducing gases, as it passes downward through the mass of burning charcoal. Such coarse grains of ore as pass, incompletely reduced, through the ignited fuel, and in this state reach the slag below, have no chance of further reduction in the forge. Hence we may conclude that the fineness of the ore should, under favorable conditions, render the reduction more complete.

The principal cause of the small yield of the Moisie furnaces is apparently to be found in the incompletely purified condition of the ore. It will be seen that the iron sand, as now prepared for the forge, may, by the use of the magnet, be divided into two nearly equal portions. One of these is magnetic, and consists, for the greater part, of magnetic oxide ; it contains over ⅔ its weight of iron, and is nearly equal in richness to the magnetic ore used in the New Russia forges. The other half is a highly titaniferous oxide, mixed with more or less silicious matter, and containing only 44 per cent. of iron ; and its admixture with the magnetic oxide, which reduces the proportion of iron in the whole to 55 per cent., appears to be not merely useless, but actually prejudicial.

When an impure ore of iron is treated in the blast-furnace, certain substances called fluxes are added, which form fusible combinations with impurities. Thus, if the ore contain silica, a sufficient quantity of lime is smelted with it, and a silicate of lime is formed, while the oxide of iron, being left free, is wholly reduced to the metallic state. In the direct method, on the contrary, no fluxes are used, and if silica be present in the ore, it combines with a portion of the oxide of iron, forming a silicate of iron, which melts into a slag or cinder, from which the iron cannot be separated in the forge. Thirty parts of silica will, in this way, unite with 72 parts of protoxide of iron, equal to 56 parts of metallic iron. In the case of the somewhat silicious ores of the Pyrenees, treated in the Catalan forge, we have seen that $\frac{3}{10}$ of the iron present in the ore pass into the slag, and the loss would be much greater did not these ores hold a considerable proportion of manganese, lime and other bases, which help to satisfy the affinity of the silica, and to leave the iron free. Such substances as these play the part of fluxes with a silicious ore, but if they are wanting, a portion of the oxide of iron itself is consumed for the purpose, forming, in fact, the only flux for the silicious impurities, when such an ore is treated by the direct method in the bloomary fire. Whenever, in the Catalan forge, the American bloomary fire, or any other direct method, we have to treat an ore containing free silica, provided other bases are not present, we must always

allow oxide of iron in the proportion already indicated, for the saturation of the silica, being at the rate of nearly 2 parts of metallic iron for each part of silica present in the ore. It is for this reason, it may be remarked, that kiln-burned charcoal is to be preferred, for the bloomary hearth, to charcoal made in the piles; the latter being generally more or less impure from adhering silicious earth, which, by combining with the oxide of iron, causes a waste of the ore.

The quartzose sand which is mixed with the iron sands, is nearly pure silica, and the oxide of titanium which they contain, appears, from the analyses of slags given below, to require, for fluxing it, as much oxide of iron as the silica itself. These slags, in case no other bases than oxide of iron are present, should approach very closely to the composition of a tribasic silicate of protoxide of iron, which, as already explained, contains 30 of silica to 72 of protoxide of iron, or 29.40 per cent. of silica, and 70.60 of protoxide, equal to 54.9 per cent. of metallic iron. The highly titaniferous slags produced at the Moisie furnaces contain, in some cases, a still large proportion of oxide of iron.

Of the following analyses, I is of a crystalline, black, brilliant magnetic slag, which contained cavities lined with large pyramidal crystals, apparently dimetric in form. It was produced at the Moisie forges in the autumn of 1867. II was a portion of the ordinary slag produced at the time of my visit, in August, 1868, and was similar to the last, but somewhat vesicular, the cavities being lined with very small brilliant crystals. Both of these slags readily gelatinized when treated, in powder, with hydrochloric acid. The residual silica, however, showed a portion of grains of undecomposed ore, which was larger in the second specimen; it was in each case deducted from the analysis. The whole of iron in both of these slags is represented as protoxide, and the results are compared with those of two analyses of the non-magnetic portion of the ore, copied from pages 267 and 268, and here given under III and IV:

	I.	II.	III.	IV.
Peroxide of iron	67.14	52 31	58.20	56.38
Oxide of manganese	undet.	2.04	.....	1.10
Lime	1.37	.....	.....	.95
Magnesia	.80	.18	.....	.....
Alumina	.....	.56	.....	.....
Titanic Acid	20.07	34.05	30.74	28.95
Silica	8.75	11.29	6.14	8.75
	98.13	100.42	.....	.....
Metallic Iron	52.22	40.68	45.26	43.85

From a comparison of the above analyses it will be seen that the first slag contains more oxide of iron than the non-magnetic portion of the ore; which, in the conditions of working, at the time the slag was produced, actually dissolved and carried away a considerable portion of the reducible ore. If we were to regard one-half of the washed ore as composed of pure magnetic oxide, this, were it wholly reduced, could only yield an amount of metallic iron equal to 36 per cent; but the magnetic ore, as we have seen, still retains more than 6 per cent of silica and titanic acid, which must be removed by fuxing with a portion of the oxide of iron present, giving rise to a certain amount of slag. Meanwhile the non-magnetic ore, in melting, removed another portion of iron oxide, so that when this slag was made, more than three tons of a mixed ore, having the composition above given, must have been consumed for the production of a ton of blooms; while, of the magnetic portion of the ore, one and a half tons, or a very little more, would suffice. (In the production of slag II the loss of iron was somewhat less.) This explains why the Moisie furnaces have yielded, when compared with those of New York and Vermont, so small an amount of iron for the labor employed

and the fuel consumed. To produce a ton of iron it has been necessary to handle twice as much ore as is required in forges where a pure ore is treated, and moreover one and a half tons, or more, of worthless material have been fused and got rid of as slag, thus involving a great waste of fuel as well as of labor. It may here be remarked that a portion of slag taken by me from the East Middlebury forges, contained, according to Mr. Broome's analysis, 48.2 per cent. of iron (equal to 62.06 of protoxide), and 16.70 of silica, besides 17.33 of alumina, and 1.82 of oxide of manganese. The amount of slag produced by the rich ores which are treated at these forges, is comparatively very small.

It would seem probable that by a judicious management of the working, the waste of iron in the slags at Moisie might be considerably reduced, and this result, we are assured, has lately been attained; but it will still remain true, that a large amount of iron oxide must be consumed to flux the considerable proportions of silica and titanic acid, which are present in the mixed ore, even after careful washing.

It should here be explained that the result would be far otherwise if this ore, with all its impurities, were to be fused in a crucible with carbonaceous matters, with, or even without proper fluxes. In the former case, as in a blast-furnace, the whole of the iron which it contains, amounting to less than 55 per cent., might, by judicious admixture, be set free, and reduced; and in the latter cases, without fluxes, it has been shown by Percy, that by fusion at a high temperature, in a crucible lined with charcoal, the tribasic silicate of iron, already noticed, gives up two-thirds of its iron, which is reduced to the metallic state, so that the amount of unreduced oxide retained by the slag would be inconsiderable. From this it is evident that the results of fire-assays, or trials on a small scale in crucibles, cannot serve as a guide to the working of iron ores in the direct method.

A certain amount of lime added to the ore, would doubtless reduce the waste of iron in the slags, and thus allow more iron to be obtained from the mixed ore; but although such an addition is useful in the blast-furnace, it would require experiments to determine whether the practice could be advantageously introduced in working in the bloomary-hearth. In a region where the ore is so abundant and so cheap as it is at Moisie, the saving of iron is a consideration which should be subordinate to the economy of fuel and labor, and the most profitable way of working these iron-sands would seem to be by separating and rejecting the non-magnetic portion, by some apparatus like that described farther on.

The quality of the iron produced at the Moisie forges is superior. As the result of experiments made upon it in England, it is said to possess a tensile strength greater than that of Low Moor iron, and to work easily both hot and cold. It is now employed at Montreal for the manufacture of railway axles.

The fact that those objectionable elements, sulphur and phosphorus, occur in but very small quantities in the iron-sand of Moisie, has already been noticed. It is probably to the absence of these that the excellence of the Moisie iron is due. In a specimen taken from a bloom which was made in my presence at the Moisie forges, the presence of sulphur could be detected by delicate tests, but its amount was only .0094, or less than $\frac{1}{10000}$; while the quantity of phosphorus present was equal to .0184 per cent. This iron contained no trace of titanium in its composition, and a small mass of white crystalline cast-iron, which had accidentally been formed in one of the forges, was equally destitute of titanium.

[TO BE CONTINUED.]

PROFESSOR KERR, State geologist of North Carolina, in speaking of Black Mountain in that State, says: "These rocks belong to the most ancient of the azoic series. The intensity of the metamorphism, the characteristic rocks and their contained minerals, together with the total absence of anything like organisms in even the least altered and latest of the series, render this conclusion inevitable. And not only do they belong to the lowest geological horizon, but the entire absence of all representatives of the latter formations makes it further necessary to conclude that we have here an extensive tract of the oldest land on the globe."

ECONOMICAL STEAM ENGINES.*

From "The Engineer."

It is at all times an ungracious task to point out the errors of those who, either from a natural perversity or from a want of accurate knowledge, persist in giving publicity to statements of a misleading character. There are, however, circumstances under which this task—ungracious though it may be—becomes a duty, and it is under what we conceive to be such circumstances that the present article is written. The readers of a contemporary of ours have been favored during the past few months with a series of articles on economical steam-engines, which must have given rise to no small amount of amusement, combined with bewilderment, in the minds of those who perused them. The main object of these articles—so far as they can be said to have any object—appears to have been to denounce the compound engine as complicated and untrustworthy; and in doing this, the writer has quoted numerous well-worn axioms, as if they were most startling and original truths, and has further taken occasion to season his compilations by descriptions of various pet schemes of his own for steam-engine improvement. Some of the earlier articles of the series just referred to, have been already criticised in our pages, and we have pointed out many of the mistatements and examples of false reasoning in which they abound. That we have allowed many of the inaccuracies contained in them to pass unnoticed, we are fully aware, the fact being, however, that we could spare neither the space nor the time that would have been necessary to correct the whole of our contemporary's errors. Even as it is, we fear we have given the subject more prominence than is acceptable to those of our readers who, being better informed themselves, can afford to laugh at the vagaries of our contemporary; but it must be remembered that these vagaries are read by numbers of the junior members of our profession, who are but too ready to accept as trustworthy all such statements and false principles as those which our contemporary thinks fit to advance, and it is in the interest of this class of our readers especially that we now write.

Last week our contemporary published what purported to be the concluding article of the series we have referred to, and in commencing this article the writer states that he proposes "to lay down a few general principles intended to serve as guides at once for the engineer making engines, and the manufacturer using steam power." Before proceeding with this very praiseworthy task, he lays down three propositions which he apparently considers to be original discoveries, and which he states he has "already endeavored to prove by argument and statement of fact." The first of these celebrated propositions is to the effect "that engines are not necessarily economical because they burn very little coal, for the construction of such engines only too often renders them liable to break down, or is certain to entail large outlays on repairs, attendance, grease, etc., which amount in the long run to more than the saving effected in coal." We can assure our contemporary that the fact that the economy of any particular engine is not to be estimated by its coal account alone, is one which was universally recognized by all competent engineers years before our said contemporary had any existence, and that any "arguments and statements of fact" which it may have brought forward to prove its pet proposition were entirely unnecessary. Although, however, our contemporary has not managed to bring forward an original proposition, it has managed to display a certain amount of originality in its method of applying the proposition to its own ends. For example, it says: "Thus, of two engines, one may burn two tons of coal a day, while another burns three tons. In the manufacturing districts coal is worth, say, 7s. a ton. The saving effected by the more economical engine is, therefore, 7s. a day. But the extra cost of grease, skilled attendance, etc., may amount to more than 7s. per day, and the apparently more economical engine will be worked at a loss." Very plausible this, no doubt, but also very inaccurate. The saving effected by a reduction of the

* See page 78, July No. of this Magazine.

quantity of coal used by one-third, is very far from being fully represented by the mere value of the fuel saved. A reduction of the consumption of coal from three tons per day to two tons, means not merely a saving of 7s., as stated by our contemporary, but it means, also, a saving of one-third in the boiler power required, of one-third in the labor of stoking, and of one-third in the amount of water required for boiler feeding, and for the purposes of condensation; this latter saving being in itself in some cases even a more important matter than the reduced consumption of fuel. On the other hand, no evidence is advanced—and, we may add, that none is obtainable—that a really well-constructed "economical" engine requires either more skilled attendance or more expensive lubrication than an engine of far less perfect construction; in fact, so far as our own experience goes, the contrary is the case. An economical engine, consuming 2 tons of coal per day, should develop at least 200 indicated horse-power, and our readers may rest assured that the cases in which a high-class engine of this power could not be employed with true economy are very rare indeed, and we, in fact, doubt their existence.

Our contemporary's second proposition is, "that it does not follow that the engine giving out the highest indicated horse-power per pound of coal burnt is the more economical, even though the cost of attendance, grease, and repairs remained unaltered, because the indicated does not represent the effective or paying horse-power, and it is this last alone which has to be considered." Now this proposition, if it means anything—a fact of which we are doubtful—means that in the more economical engine there will be a greater proportion of the indicated power expended in overcoming internal friction than is the case with its less economical rival; but it is most certainly curious that if this is the case the cost of "grease and repairs" should remain the same in the two instances. Our contemporary's second proposition, therefore, is self-contradictory.

We now come to our contemporary's third proposition, which is to the effect: "that the cost of a first-class engine may be so great as to deprive the honest manufacturer of any chance of selling." This is no doubt partially—but only partially—true. A first-class engine may be made to cost almost any sum, but by avoiding all unnecessay finish a really economical engine can be produced at a cost which is but very little in advance of that of engines of most ordinary construction. Moreover, the fact that any difficulty is experienced in disposing of high-class engines is to be attributed not to such engines not being worth the sums asked for them, but to the ignorance of their real value exhibited by those who ought to employ them. Under these circumstances it is the duty of the professional journalist not to advocate the increased production of engines whose sole recommendation is their cheapness; but rather to endeavor to open the eyes of employers of steam-power to the important advantages which they are in but too many instances sacrificing to a slight saving in first cost. That a vast number of cheap engines are manufactured and sold profitably is no doubt true; but except, perhaps, in the case of small powers or when required for temporary purposes, we know of no case in which such engines can be employed with advantage to the purchasers. This, however, is a question with which we have dealt fully in former articles, and we shall, therefore, pass on to consider some of the principles which our contemporary lays down as guides for engineers making engines.

Our contemporary makes a good start by recommending the horizontal form of engine, and by further recommending that the cylinder should be kept hot and dry. There is nothing, however, very original in these recommendations, and to atone for this want of originality apparently, our contemporary proceeds to describe an arrangement which it states is "now, we believe, proposed for the first time." This arrangement our contemporary describes, as consisting "in jacketing the steam pipe, that is to say, enclosing the steam pipe within another a couple of inches larger in diameter and carefully lagged." How many years have passed away since the time when the proposal to jacket a steam pipe would have been esteemed a novel one we are unable to state; but we venture to say, that our contemporary's notions as to how such jacketing should be carried out possess undoubted claims to originality. Lest our readers should think that we are

quizzing them, we give the description of the proposed arrangement in our contemporary's own words, which are as follows: "The pressure in this pipe [that is the jacket] would be always that in the boiler, but the pressure in the steam pipe is of necessity always a little less, and the fluid on its way to the engine would, therefore, always be exposed to a slight superheat; a small cock should, of course, be fitted to draw off the condensed water [query condensed *steam?*] from the outer pipe. The inner pipe having only the difference between the boiler and the valve chest pressures to withstand, might be made very thin, as it would always be in compression [the very reason why it should *not* be made thin, we should have thought], and the boiler stop-valve would, of course, be common to both, so that steam could not enter one without the other." It is certainly difficult to believe that such a proposition as this could have been made otherwise than as a joke, yet we find our contemporary recommending the arrangement in all seriousness as "a static improvement," and further asserting that it "would be found unlikely to get out of order and very cheap to make!" From our contemporary's description it is evident that, as the boiler stop-valve is to shut off the supply of steam to both, the steam-pipe and jacket must be in free communication with each other, and it would have been gratifying to inquiring minds if our contemporary had condescended to explain how, under these circumstances, the excess of pressure in the jacket necessary for superheating purposes was to be obtained. Further, the author of the brilliant suggestion we are considering, speaks of the inner pipe being made thin on account of its having to withstand only a slight excess of external pressure; but if he takes the trouble to refer to a table of the temperatures of steam, he will find that at the ordinary pressure at which boilers are worked, an excess of pressure in the jacket of even 5 lbs. per square inch, would give him less than 5 deg. difference of temperature, and we should like to know of what service this 5 deg. would be for superheating purposes. The whole plan proposed is, in fact, simply ridiculous, and to our contemporary's query: "If a cylinder is to be jacketed why not a steam-pipe?" we need only reply, "Read some some elementary work on the steam-engine and find out."

Next says our contemporary: "Having got dry, clean steam [we presume with the chill taken off by the beautiful arrangement above described] it remains to be seen what we shall do with it." Just so, and having read the remainder of our contemporary's article, we have come to the conclusion that this fact "remains to be seen" still, as far as he is concerned. The article contains many unsupported assertions, but no specific information, and the writer appears to have entirely forgotten that this supply of "dry, clean steam" remained to be disposed of. Thus we are informed that uncompounded engines do not do as well as compound engines, simply because the former are "not worked with steam in the condition of a perfect gas," a state of affairs which we presume the original arrangement we have alluded to is designed to remove. Further, we are informed that compound engines are "invariably compared with single engines with unjacketed cylinders:" a "fact" which, we fancy, will take many of our readers by surprise. Our contemporary also states that: "The real advantage, such as it is, of the compound engine, is that it saves the engine from shock, and equalizes the strain and driving power; but the same end can be attained in other and cheaper ways, even with large measures of expansion." What these "other and cheaper ways" may be, the writer does not condescend to explain; but we are glad to see that he does not again repeat his proposal to use enormously heavy fly-wheels, the absurdity of which we exposed in our article entitled "Wonderful Fly-wheels," which appeared in this journal a few weeks ago. Evidently the few simple statements we then made have been appreciated, and we can assure our contemporary that, actuated as we are by a desire to spread useful knowledge, this fact more than compensates us for having devoted space to the elucidation of such exceedingly elementary principles.

THE subscriptions to the fund for defraying the expenses of the proposed inquiry by the British Association Committee on Sewage amount to above 12,000*l*. The inquiry will be commenced at once.

THE UNIT OF LENGTH.

From "Nature."

The battle of the Standards is over, and we may say the Metre has gained the victory. The need of a new system of weights and measures to amend the strange diversities which disfigure our practice being admitted, the question has once more been started—Should we once for all found our system on a natural basis? The pendulum vibrating seconds in a certain latitude, was long ago proposed as a universal basis of linear measure, and the House of Commons somewhat countenanced it years ago, by prescribing that the length of the yard shall be determined by the length of the second's pendulum. But the action of gravitation, on which the terms of the vibration depends, is subject to so many variations and disturbances, that the quantity sought cannot, even on the same spot, be absolutely the same at all times. The real length of a normal pendulum is almost unattainable, so limited is our knowledge of the force of gravity on land and at sea. A more certain basis for a natural unit has been found in the polar axis, the length of which, according to Sir John Herschel, bears a close relation to our imperial inch, and has the advantage of avoiding the many causes of error resulting from the physical peculiarities of the countries through which any measured arc may happen to pass. But are our physicists agreed as to the real length of the polar axis, and would it be worth while to make any alteration in our weights and measures for the sole purpose of attaining some scientific correspondence between the unit in use and a unit founded on nature?

The advocates of the metre rest their arguments on a much broader basis. They do not assert that the metre is absolutely and mathematically the ten millionth part of the quadrant of the earth; they know that the meridians of places differing in longitude are not all precisely of the same length; and they admit that were we now to make a new measurement with our better instruments and more extended information, we might attain much greater accuracy than was arrived at by the French philosophers at the end of the eighteenth century. What commends the metre above any other unit, is the fact that it is already a cosmopolitan unit, widely recognized, and in general use among many nations; and that whilst other units remain as philosophical abstractions, the metre is the basis of a system, not only perfectly complete, homogeneous, and scientific, but simple and practical in all its parts. Any slight error in the determination of the metre, is more than counterbalanced by the extreme simplicity, symmetry, and convenience of the metric system; and not the least of its recommendations are, that the unit of linear measure applied to matter in its three forms of extension, viz., length, breadth, and thickness, is the standard of all measures of length, surface, and solidity; and that the cubic contents of the linear measure in distilled water at a temperature of great contraction, furnish at once the standard weight and measure of capacity.

When we said that the battle of the Standards is over and that the Metre has gained the victory, it was meant that, for practical purposes, all opposition to the introduction of the metric system has been abandoned, and that Parliament and the Government are now left to introduce it in such a way and at such a time as may be found at once practicable and satisfactory. The use of the metric system has been legalized for the last half-dozen years, but it was not till quite lately that the whole question was submitted to the calm deliberation of a Royal Commission. The Standard Commissioners, who included among their members the Astronomer Royal, the President of the Royal Society, and the late Master of the Mint, considered the question of the introduction of metric weights and measures, in any form, *ab initio*. And after careful examination they gave their verdict in its favor in the following terms:—

"Considering the information which has been laid before the Commission—

"Of the great increase during late years of international communication, especially in relation to trade and commerce;

"Of the general adoption of the metric system of weights and measures in many

countries, both in Europe and other parts of the world, and more recently in the North German Confederation and in the United States of America ;

"Of the progress of public opinion in this country in favor of the metric system as a uniform international system of weights and measures ;

"And of the increasing use of the metric system in scientific researches and in the practice of accurate chemistry and engineering construction ;

"We are of opinion that the time has now arrived when the law should provide, and facilities be afforded by the Government, for the introduction and use of metric weights and measures in the United Kingdom."

The Commissioners further recommend that metric standards, accurately verified in relation to the primary metric standards at Paris, should be legalized ; that verified copies of the official metric standards should be provided by the local authorities for inspectors of such districts as may require them; and that the French nomenclature, as well as the decimal scale of the metric system, should be introduced in this country. The Commissioners, whatever might have been their predilections, could not resist the fact that the civilized world pronounced itself for the metre, and they sanctioned its legalization. What is to be regretted is that they stopped there. Since the complete substitution of the metric for the present practice is now practically certain, would it not be much better to prepare for the change and carry it into effect as speedily as possible? No advantage can come from a policy of indecision, and we trust that the Legislature may adopt a more definite course than the one sketched out by the Royal Commissioners. Let it not be imagined that the people will give themselves the trouble of learning the new system, however beautiful and easy, so long as its use is not absolutely necessary. With all the desire of the teachers to introduce it in the schools, they find that they cannot teach the old and the new tables. They cannot afford the time. A compulsory measure is the only method of dealing with the question.

The Warden of the Standards being now employed in procuring Metric Standards, it may be well to add that the mode of constructing them, either from the original Metre at the Archives, or from the copy at the Conservatoire des Arts et Métiers, has been much debated. The International Statistical Congress, held at Berlin, decided "That the care of preparing and putting into execution the regulations to be followed in the construction of the standards, and of the system itself, should be intrusted to an International Commission, which will also see to the correction of the small scientific defects of the system." The International Geodesical Conference, held at Berlin in 1867, decided : "In order to define the common unit of measures for all the countries of Europe, and for all times, with as much exactness as possible, the Conference recommends the construction of a new prototype European Metre. The length of this European Metre should differ as little as possible from that of the Metre of the Archives in Paris, and should in all cases be compared with the greatest exactness. In the construction of the new prototype standard, care should be taken to secure the facility and exactness of the necessary comparisons." And "the construction of the new prototype metre, as well as the preparation of the copies destined for different countries, should be confided to an International Commission, in which the States interested should be represented." Since then, the Imperial Academy of Science of St. Petersburg has taken the matter in hand, and a committee of the Physico-Mathematical class, consisting of MM. Struve, Wild, and Jacobi, has made a report on the subject, observing that the standard metric weights and measures of the various countries of Europe and of the United States differ by sensible though small quantities from one another. They expressed their opinion that the continuation of these errors would be highly prejudicial to science. They believed that the injurious effects could not be guarded against by private labor, however meritorious, and they recommended that an International Commission should be appointed by the countries interested to deal with the matter.

ACCORDING to M. Saint Deville, the oxygen dissolved during the fusion of platinum causes the metal to spirt as in the case of molten silver.

THE CHEMICAL TREATMENT OF SEWAGE.

From "The Mechanics' Magazine."

In whatever manner the removal of sewage from the vicinity of habitations and dwellings may be effected, there yet remains the subsequent utilization of it to be accomplished before it can be said that this great national question has been dealt with commensurately with its extent and importance. One of the primary objects to be insured, except where irrigation is made use of, is its purification. Various plans have been devised, patented, and experimented upon with this end in view, some of which have been partially successful, but not a single one can be candidly said to have fulfilled all those conditions necessary to constitute a perfect success. At present we propose to consider those plans for the purification of sewage which adopt as the basis of their treatment the employment of chemical reagents. What is aimed at by the chemist is the extraction, conversion, and production of an artificial fertilizer. He is well aware that all the elements of a valuable manure exist in sewage, and he is therefore anxious to treat it in such a manner as to cause it to yield a really fertilizing manure in a portable, a marketable, and a remunerative form. As yet very little success has attended these efforts. The estimate of the valuable properties of artificial manure manufactured from sewage which is formed by the chemist has hitherto been enormously in excess of that which is put upon it by the practical farmer and agriculturist. The latter being the purchaser and consumer, his estimate of it is the one which finally settles the question respecting its real utility and value. It is obviously to no purpose for a chemist or an analyst to put a certain theoretical value upon a product or manufactured article which it fails to possess in practice, if, as is the case, the cost of its production is to be defrayed out of the sum for which it sells. In all similar operations preliminary experiments are indispensable to arrive at a correct estimate of the result, but a time must come when the experiments must cease and some tangible return be made for the outlay incurred. A large amount of unproductive capital has been already sunk in vain endeavors to accomplish the production from sewage of a salable artificial manure, and rate-payers and local boards naturally object to risk the loss of further sums.

In the purification of sewage the object is to extract from the fluid medium the offensive and noxious ingredients which are contained in it, and which are also the valuable components for the manufacture of an artificial manure. These ingredients may be divided into 2 classes, those which are chemically dissolved in the fluid, and those which are merely mechanically suspended in it. The former of these are the most rich in manurial properties. They consist of the various forms of combined nitrogen with a variable proportion of phosphoric acid. The relative value of the 2 classes of ingredients is readily seen from the fact that in 100 tons of sewage, the disolved constituents are worth 15s., while those held in mechanical suspension are not worth more than 2s. Manifestly, when we regard the great disproportionate value of these 2 principal components of sewage, the efforts of the chemist are chiefly directed towards effecting the extraction of the former. Moreover, it is in this particular that lies the main difficulty. Mechanically suspended substances are easily removed by filtration, but as they do not contain more than a seventh of the real fertilizing ingedients, it is clear that they would never repay the cost of their extraction. There is another point to be attended to with respect to the chemical treatment of sewage, besides that already mentioned, of manufacturing a manure from it. It is the rendering of the residue or effluent water sufficiently pure to allow it to be discharged into the nearest river or watercourse of the country. It is very questionable whether this has been practically effected by any method save that of irrigation, although there is no doubt that many of the processes in use, or under experiment, do purify the water to a considerable extent. The removal of the suspended matters alone does not effect an adequate purification of sewage water, since the dissolved impurities contain most of the offensive and putrescible ingredients in more than sufficient quantity to cause a nuisance. If a

genuine salable manure were once produced there is no doubt that, as a necessary consequence, the effluent water would be purified to a degree that would permit of its being discharged into rivers and streams without fear of pollution. The reason of this is plain ; as it is only by the extraction of the noxious and offensive ingredients that a good fertilizer can be produced from it, it is similarly only by their removal that the effluent water becomes purified. The one is an inevitable result of the other.

Among the various processes that have been tried, and some of which are in present operation, may be mentioned the "lime" process, that of Sillars (also called the A B C process), that in which lime is used in combination with chloride of iron, that of Holden, and one or two others in which sulphate of alumina, sulphate of iron, coal dust, and other ingredients are employed. With respect to these chemical treatments it cannot be said that any of them have proved wholly successful, neither can it be said that they have all eventuated failures. Some certainly have been demonstrated by experiment and analysis to be totally inadequate to produce either a salable manure or to purify the effluent water to an extent that will allow it to be discharged into streams without fear of pollution. From the experiments conducted at Leicester by the Rivers' Pollution Commissioners the following very important results in connection with the two processes of the "lime" and the A B C were arrived at. The lime process considerably reduces the amount of dissolved impurities in sewage, while by Sillars' process these impurities are markedly increased. Both processes diminish the amount of organic carbon, and this is effected by the A B C treatment in a more complete manner than by that of the lime. The chief dissolved constituent of sewage that constitutes the most active element in the pollution of watercourses is the nitrogenous organic matter. This is the ingredient that becomes putrescent with the greatest rapidity, which it is most essential to remove. Both processes "signally fail" to remove this element of pollution to a degree that would render the effluent water fit to be discharged into a river. At the same time the sewage is purified by both to a certain extent, and it is possible that a further improvement may yet take place. Regarding the other question of the production of a salable manure, the superiority lies with the A B C process, which, notwithstanding that there is a loss of nitrogenous organic matter, "yields a solid manure of much greater value than that obtained by the lime process." Their separate values are per ton £1 13s. 0¾d. for that manufactured by the Sillars process, and 13s. 6¼d. for the product yielded by treatment with lime. Notwithstanding this difference in monetary value, the A B C process "fails to extract from the liquid more than a very small fraction of its valuable constituents." This might be anticipated from the price per ton, for were the manure rich in fertilizing properties it would fetch considerably more money in the market. It is also clear that if the cost of manufacture be deducted from this sum it cannot leave much of a balance on the credit side, even if it does not come out on the wrong page of the ledger.

A process in which sulphate of iron, lime, and coal dust are used is known as Holden's process, and has been tried in Bradford. Similarly to its rivals, it separates the whole of the suspended matter, but there its advantage appears to end. A very curious effect is produced by this treatment upon sewage, and one which is particularly worthy of notice, as it proves that it is quite possible to increase the noxious and offensive features in sewage by a so-called purifying operation. This process "not only fails to remove the putrescible organic matters in solution, but actually increases their quantity. The effluent water could not therefore be admitted into rivers without causing pollution." Since this process only extracts the suspended constituents of sewage, the manure formed from it cannot have any considerable fertilizing powers, as the suspended matters contain only about ¼ of the valuable qualities possessed by those held in solution. From these facts, which may be regarded as incontrovertible, it is manifest all these processes appear to be tending in the right direction; but, possibly from the comparatively small amount of actual experience they have undergone, the means to their ends are not yet properly organized and comprehended. It would be unfair to expect that so great a problem as the disinfection and deodorization of

sewage, together with the subsequent purification of the effluent water, could be possibly accomplished all at once. Each step towards that result must be a question of time; but whenever that step is gained it must be borne in mind that it is gained for ever. Irrigation certainly solves the problem, as no artificial mixture and combination will ever prove so thorough a purifier of sewage as the natural absorbent and assimilating powers bestowed upon the soil and plants. In many instances irrigation works assume proportions that frighten the boldest speculator, and the difficulty must be met in the interim.

ORIGIN OF GOLD NUGGETS AND GOLD DUST.

By ANDREW MURRAY, F.L.S.

From "The Scientific Opinion."

The origin of gold nuggets and gold dust is not so simple or clear as at first sight it appears to be. The natural explanation of the production of gold dust is that it is the golden portion of the *debris* of rocks which have originally had gold disseminated through them. As the wear and tear of ages has crumbled into dust mountains so composed, part of the dust becomes sand or quartz, or whatever else the basis of the rock may be, and the other part is the liberated gold from which the quartz has been rubbed away; and if we accept this as the explanation of the production of gold dust, the same hypothesis should explain that of gold nuggets which are found associated with it.

But there are various circumstances which it is difficult to reconcile with this theory. One of these is the occurrence in the drift of nuggets of a larger size and less intermixed with foreign substances than have yet been discovered in any quartz reef; as most people are aware, the gold in reefs is usually disseminated in particles and strings through the quartz veins or rock, instead of lying in pockets or masses. Another still more remarkable fact, applicable both to gold dust and gold nuggets, is that alluvial gold is generally of a higher standard than that obtained from the reefs. It is needless to say that if it is merely the gold washed or crumbled out of these reefs, it ought to be of identically the same standard and quality. Another objection to the dust being merely the degraded particles released from the rock is the size of the particles—not nuggets, but particles of dust. Gold being so much softer than quartz, its particles after being subjected to the same degree of attrition ought to be vastly smaller; although of greater toughness than quartz, and possessed of ductility and tenacity which quartz wholly wants, it is very soft, and, under the influence of the attrition from running water and its accompaniments, ought to be pounded and torn into the minutest fragments; but this is not so. There is, moreover, a marked difference in the appearance of the gold dust from different drifts in different countries. In some it is like dust or sand, in others it is like scales. If subjected to the same influences in all, there seems no reason why the same shape should not obtain in all.

These peculiarities would suggest that some other influence than mere degradation of gold-charged rocks has been the agent in producing gold dust; but in any and every view we think it cannot be disputed that degradation must have had some share in the work. It is plain that if a gold-charged rock is reduced to gravel, sand, or powder, particles of gold of some size or other, or gold in some shape or other, must form part of the *debris*. These gold remnants should be found in greater quantity and in greater size the nearer they lie to the source from which they were drawn; and this we believe also to be the case. The general similarity between gold-producing districts, by which a Californian miner could detect a likely spot for gold in Australia or Kildonan, probably depends rather on the character of the mountains out of which the gold has come than on the mode of production of the manufactured dust, if we may call it so. We imagine that the truth will be found to be that the result is referable to two causes, only one of which may in some cases have been present, in others both;

the first, the ordinary process of degradation and grinding the rock to fragments; the other, as suggested by Mr. Selwyn, the Government geologist of Victoria, that gold has also been taken up in solution by the water permeating the gold-bearing rocks, and that in passing through the drift, in which minute particles of gold lay, it has from some cause become decomposed, and the gold held in solution been precipitated and deposited around the most congenial nuclei presented to it, which would undoubtedly generally be the particles or pieces of reef gold, or any other metallic substances for which it had an affinity.

We find an interesting paper on this subject in the "Transactions of the Royal Society of Victoria" (1867), by Mr. C. Wilkinson, in which he mentions some facts bearing on the subject. It appears that Mr. Daintree, formerly of the Geological Survey of Victoria, had on one occasion prepared for photographic uses a solution of chloride of gold, leaving in it a small piece of metallic gold undissolved. Accidentally, some extraneous substance, supposed to be a piece of cork, had fallen into the solution, decomposing it, and causing the gold to precipitate, which made a deposit in the metallic state, as in the electro-plating process, around the small piece of undissolved gold, increasing it in size to two or three times its original dimensions. Considering this accidental experiment of Mr. Daintree's as in some measure supporting Mr. Selwyn's theory, Mr. Wilkinson followed it up by a few simple experiments in the same direction, which he details in his paper. In his experiments a small chip of wood was generally used as the decomposing agent. In one instance he used a bit of leather. All through the wood and leather, gold was disseminated in fine particles, and when cut through, the characteristic metallic lustre was highly reflected. From various experiments it would appear that organic matter is the necessary chemical agent for decomposing a solution of the chloride of gold in order to precipitate the gold as a coherent coating around a nucleus; and that, so far as Mr. Wilkinson had yet tried, iron, copper, and arsenical pyrites, galena, antimony, molybdenite, blend, wolfram, and metallic gold constitute essentially favorable nuclei to determine this chemical reaction. It is to be observed, too, that organic substances, such as fragments of wood, roots of trees, etc., occur abundantly in the gold drifts of Australia. If water holding gold in solution circulates through the rocks and drifts, all the conditions necessary for the production of gold dust and nuggets by deposit are present. Does the water so circulating now hold gold in solution? One would think it would not be difficult for a chemist in Australia or California to determine the fact by direct experiment, but it does not appear that it has ever been tried. Mr. C. Wilkinson, however, quotes facts which lend probability to the view that when the trial is made, the question will be solved in the affirmative. In testing a solid mass of iron pyrites, Mr. Daintree found gold throughout. This mass retained the structure of a tree-stem, in which the organic structure was replaced by pyrites. It had been taken from the Ballarat drift, and the same experiment was repeated by Mr. Newbury, the Geological Survey analyst, on another stem taken from the same drift, with a like result. Gold in such deposits assumes a mammillary form, which appears analogous to that presented by the surface of nuggets—a point of some importance, for, in the first place, it is a question whether a mammillary surface is the kind of surface that would be produced by abrasion and attrition; and, in the next place, abrasion or attrition can certainly have nothing to do with its appearance in these golden petrifactions. We cannot avoid attaching the greatest importance in relation to the question, to the presence of gold in pyrites that has been formed in wood imbedded in auriferous drifts. The gold *must* have been in solution when so deposited, and everything will then depend on the age of the so petrified wood. If contemporaneous with the drift, the question is answered. Another fact to the same effect is, that sometimes gold incloses a nucleus of brown iron, etc. This is obviously quite inconsistent with such pieces of gold having been abraded, as they are out of crumbling rocks; such nucleated pieces of gold are never found in reefs. It is the old puzzle of a reel in a bottle.

In relation to this we may remark that we believe that nuggets have never been found in the gold-fields of Brazil. We have the authority of Mr. Harding (a

gentleman well known for his great practical knowledge of gold mines and mining in that country) that he never met with nor heard of a nugget properly so called in all his many years' experience in the gold district of Brazil; but, on the other hand, it is there almost invariably found in veins in connection with, or in the vicinity of, some other metal—generally iron. In what is probably the most prolific mine of gold that has ever been known in the whole world, that of San Juan del Rey (the value of which was not very long since so seriously depreciated by the accidental destruction by fire of the wooden ladders, supports, and machinery), the gold is found in a matrix of porous iron or agglutinated iron sand called Jacotinga, which consists of a bed or vein, not a foot in width, but so incredibly rich that on one occasion, when our informant was on a visit to the manager, there was brought in on an assiette, as a sort of dessert for the eyes after dinner, a lump of gold ore that had been extracted that day from the mine. It was about the size of a large fowl, not so big as a turkey, but bigger than a duck. It was a mass of Jacotinga-iron with gold all mingled and streaked through it. The gold when afterwards extracted was found to amount to 30 lbs. weight. On the previous day the amount of gold obtained from the Jacotinga had been 67 lbs., and on the day following 130 lbs., equal in value to about £8,000. We only mention it as a corroborative instance of the concurrent presence of gold and iron. Lastly, as pointed out by Mr. Wilkinson, it must be admitted that the fact that gold may be greatly purified by dissolving and reprecipitating it, is very suggestive of the generally higher standard of alluvial over reef gold being due to a similar cause.

EXTRACT OF TAR AND PRODUCTION OF PARAFFINE, ETC., BY MEANS OF STEAM.

From "The Engineer."

A long series of experiments has been carried on in Germany with the view to a more economical mode of extracting essences from lignite, and M. Ramdohr has given an account of his process by means of superheated steam.

His superheater for an apparatus of 8 or 9 tons, consists of a number of drawn iron tubes, rather more than 1½ in. in diameter, and placed in three parallel rows; the tubes are placed rather more than 1 in. apart, and those in the middle alternate with those of the upper and lower tiers, so that the flame must act on all sides of the tubes, the joints and ends of which are protected from the direct action of the fire. There is a difference of 2.5 to 2.8 atmospheres in the pressure of the steam at its entrance and exit from the superheater. The flame acts upon the tubes from above downwards, so that the heat attacks first those tubes which contain the cooler steam. Tubes made of iron ⅜ in. thick will last about 8 or 9 years, and with a thickness of ½ in. rather more.

The extractor is a cast-iron chest from 70 in. to 7 ft. long, 3 ft. to 3 ft. 8 in. wide, and 3 ft. to 4 ft. high; at a short distance from the bottom is a sort of grate, upon which the coal is laid to a depth of 24 in. to 40 in.; at the upper part is a tube large enough to allow of the escape of the vapor of the tar and steam through a valve into the condenser. In the front of the chest are three rectangular openings, each nearly 30 in. wide, but of different heights; the first of these is beneath the grate, and serves to remove any pieces of coke which may fall through; the second is level with the grate, and serves to feed the fire and withdraw the coke; and the third is level with the upper layer of coal, most of which is introduced by this orifice. All three are luted with clay.

The superheated steam is introduced below the grate, and gradually traverses the whole mass of coal.

The apparatus now in use contains about 8 tons of lignite of Aschersleben, but M. Ramdohr is constructing one to contain 20 tons, and so arranged as to act with the smallest quantity of water possible; he hopes with this to treat at least 9,000 tons of lignite per annum.

The condenser is peculiar in form; it consists of two ordinary tubes united to

each other by a large number of others ; one of the former is completely surrounded by a small quantity of water, while the other is in contact with the air. The vertical tubes pass through a closed iron case measuring nearly 7 ft. in length, and over 2 ft. in width and height ; this case stands in an open vessel, a space of 3 in. between the two, which is also the diameter of the vertical tubes.

The tubes and this intermediate space are filled with water constantly flowing upwards, and the space between the tubes and the case is in communication with the distilling apparatus, the steam and the vapor of the tar passing in the reverse direction to the water, viz., from above downwards. The water enters the condenser at a temperature of 50 deg. to 60 deg. and leaves it at about 194 deg. Each operation requires 12 or 13 hours, including the mounting of the apparatus and the collection of the products.

By simple arrangements the progress of the operation may be observed at any moment, and in each portion of the apparatus, so that the coke is never withdrawn until it is exhausted ; this is effected by means of bag-like projections on the tubes provided with small stopcocks. During the first two hours after the superheated steam is let in, nothing is disengaged but the humidity contained in the mineral, and consequently the stopcock only gives forth water ; presently the tar appears in the form of a thin stratum of dark olive or coffee color, which goes on increasing until towards the end of the operation, when it falls off, and is finally replaced by a mass of flocculent yellow matter.

All the liquid products of distillation are received in the same vessel, but the water separates itself and is drawn off from below by means of a siphon, while the tar runs off by a cock. The yield of tar varies between 19 kilos. and 21 kilos. for every 150 kilos. of lignite. The cost of producing 1 cwt, of tar clear of water is about 6s. 8d. with coal at 54 cents. the 3 cwt., but with coal at 42 cents the expense is not more than 5s.

The tar, as it is called, obtained by this process, is very different from that obtained by retorts ; it solidifies at 130 deg. to 140 deg., so that even in summer it is kept in the open air in great cakes between 4 ft. and 5 ft. long, and 4 in. thick, and these cakes are often stacked one on the other. The specific gravity at 194 deg. is 0.875. Its chemical composition differs much from ordinary coal tar.

According to the inventor's theory the object of distillation is not to disengage the paraffine and the crude oil from the lignite, but that which serves as the basis of the preparation of paraffine. To obtain tar, distillation is necessary, and each distillation of substances already rich in paraffine gives rise to separations without disengagement of carbon. Tar which already contains paraffine and crude oil gives rise at a first distillation to a separationof these substances, but tar which does not contain these carburets ready formed, but which includes the resin, which is the true source of paraffine, will lose much less paraffine in a well-conducted first distillation, because this substance is not, in fact, formed until the tar has reached its boiling point.

There is a very simple method of ascertaining if a given sample of tar is true tar ; that is to say, a pure vegetable resin, or a mixture of resin with crude oils and raw paraffine ; true tar has the properties of an acid, and will combine with alkalies, and undergo saponification, properties which the neutral bodies, mineral oil and paraffine, do not possess. Gas tar will saponify only partially when treated with caustic alkali or soda lye, about 80 per cent. of the whole separating and floating in the tar-soap ; the former consists of crude oil and raw paraffine, which are found in large proportions, because in the retort the tar which is disengaged from the carbon has already submitted to partial decomposition. In good tar obtained by means of superheated steam nothing of this sort happens, it contains no trace of paraffine or crude oils ready formed. M. Ramdohr believes that the value of tar is not so clearly indicated by specific gravity as by the absence of hydrocarbons in the liquid or solid state.

Down to 1868, M. Ramdohr treated the tar in the following manner :—It was distilled and the product first washed and then acidulated ; the mass thus produced, was then submitted to a first fractional distillation, the oils were immediately rectified over soda without any other chemical treatment, and the mass of paraffine crystallized. The oils, rich in paraffine, which were obtained from this substance

by pressure, were collected in the ordinary manner and crystallized as often as necessary. By this process he obtained very fine paraffine, the average of 6 years' working being 15 per cent., namely 10 per cent. at the first distillation at a temperature of about 129 deg. or 130 deg., and 5 per cent. by two subsequent distillations at a heat of 100 deg. to 118 deg. The oils formed about four-tenths in weight of the tar treated. Further experiments enabled him to obtain fine paraffine by a single distillation of tar, but this required too much time; finally, he discovered the new method of treatment which he has employed for a year or more with successive improvements. The average of 9 months' working gave him 22 per cent. to 24 per cent. of paraffine, 15 per cent. obtained at between 133 deg. and 137 deg. or 138 deg., and 7 per cent. to 9 per cent. of secondary product obtained between 100 deg. and 118 deg., with 36 per cent. to 38 per cent. of oils of all kinds. He hopes to obtain from tar extracted by means of superheated steam 28 per cent. to 30 per cent. of paraffine and 2 per cent. to 34 per cent. of oil.

A NEW ROTARY PUMP.

From "Les Mondes."

This machine works very simply, and after the manner of certain canals in the animal economy, imitating the vermicular or peristaltic movements of the intestines in their spontaneous motion which aid digestion.

Revolving arms, turned by a crank, carry friction rollers, which, in rolling upon an elastic tube, press before them the liquid or gas that it contains, while the tube, regaining its form after the compression, exerts an aspiration proportioned to the elasticity of its sides.

The plan is admirably adapted to all the requirements of storing or transporting wines.

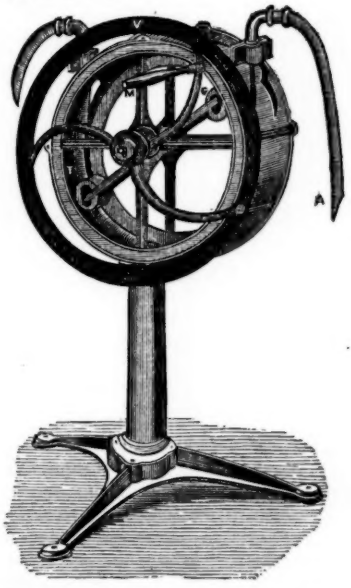
For this use it offers the following advantages:

1*st*. The wine traverses the pump without shock (batter); an important consideration, and belonging especially to this machine. While in ordinary pumps the wine sustains considerable beating and jolting, in this new apparatus it passes over as in a siphon, and flows without encountering any obstacle, in an open canal.

2*d*. The wine undergoes no alteration by its passage through the tube; long experience having proved that the rubber of which the tube is made cannot injure the most delicate wine.

3*d*. There is no contact of the liquid with any oxidizable metallic surface, nor with greasy coated surfaces, such as, unfortunately, occurs in all other present systems.

4*th*. This pump yields a greater useful effect, in proportion to the force applied, than any other pump, whether reciprocating or rotary.



5*th*. When it is desirable to empty the conducting tube, as when a cask has been filled, it is only necessary to reverse the motion of the pump, and the excess of wine is returned to the reservoir. This manœuvre, so simple and so advantageous, is impossible with any other system.

6*th*. The tube is easily and promptly filled.

7*th*. It serves to agitate the wine at the moment of sizing, by forcing through the siphon a powerful current of air.

8*th*. Finally, this new wine-pump requires no care to keep it in order; it can be cleaned with facility, or repaired, if necessary, without having recourse to a special workman; the replacing of the rubber tube, after very long use, being all that is necessary.

This pump was invented by MM. Mackintosh & Guibal, the celebrated rubber manufacturers. It has been extensively used by wine and beer manufacturers, who testify to its advantages. By using porcelain rings for ends and joinings, it may be used in pumping vinegar. If prepared rubber be substituted for the natural product, the pump will be very serviceable in raising petroleum and similar oils.

THE GREAT NORTHERN TELEGRAPH CABLE.

From "The Engineer."

Now that the understanding which is to supply, or, at any rate, to assist in, the establishment of the long needed telegraphic communication between the Chinese ports and the Continent of Europe, has so far advanced toward completion that the vessel with the first section of the cable has actually sailed, a few facts detailing the measures that have been taken for achieving the objects for which the Great Northern Telegraph Company has been established may not prove uninteresting. It is exactly six months since the Danish frigate Tordenskjold was despatched from Copenhagen, and cast anchor in the Thames as the pioneer vessel in the expedition. The Tordenskjold is said to be the finest frigate in the service of his Danish Majesty; but it may be remarked that in both appearance and size there are many among the old wooden vessels in the British navy not pretending to the title of "frigate" would completely surpass her. This will be readily understood when we mention that she is but 160 ft. in length and 42 ft. in beam amidships, with a capacity of 1,435 tons. In general appearance she is strikingly unlike what a closer inspection proves her to be, a screw-steamer, chiefly from the large size of her masts and the comparative diminutiveness of her funnel. In fact, under present conditions, that is with the greater part of her armament removed, this vessel might well be taken or mistaken for one of those Australian or East India clippers with which "Greens" and "Wigrams" have familiarized us of late years. However, frigate or otherwise, the Tordenskjold is evidently well adapted for the work she is now engaged upon, and if ever called upon to fulfil the duties for which she was originally designed, we have no doubt that she would not be found wanting. The other ships engaged in the work of laying the cable are the English screw-steamers Great Northern and Cella. These vessels both surpass the Tordenskjold in dimensions, the first named being in length 243 ft., in beam 32 ft.; and the second 300 ft. long, and 34 ft. in beam. The Great Northern, which is lying in the Thames, at Charlton, off the wharf of Messrs. Siemens Bros.—the firm who have been intrusted with the construction of the cable—is now being fitted with the tanks, drums, windlasses, and other apparatus necessary for the work she is to undertake. The scene on board at the present time is one of the most picturesque confusion; on one part of the deck may be observed the instrument room, from whence it will be possible to detect the slightest fault in any portion of the cable during the process of submersion, and these instruments are being fitted up by an entirely different class of workmen to those who are to be seen close by placing in position, with the aid of screw-jacks and levers, accompanied by the expenditure of much "undefiled Saxon," the engine which is to aid in the process of transferring the cable from the factory to the vessel. After having glanced at the various objects on deck, the visitor's attention will be drawn to seven enormous chasms. These extend downwards from the main deck into the hold, and are the tanks in which the cable will be coiled during the outward voyage.

From the vessels that are to lay the cable the natural transition is to the cable itself. This, with the exception of the completed portion despatched on board

the Tordenskjold, is in course of manufacture by the firm to whom we have already referred, Messrs. Siemens Bros., of Westminster, and the Charlton Telegraph Works. It consists of three distinct divisions, known respectively as the main cable, the intermediate cable, the ordinary shore end and the heavy shore end. Of these the "core"—through which the actual transmission of the electric current is effected—is the same throughout, the distinction arising from the different methods adopted of "sheathing," or protecting this core according to the varying liability to exposure and injury. The core consists of a strand of seven copper wires, cased with tin, weighing 300 lbs. the nautical mile, covered with the composition known as "Hooper's Dielectric," which of itself weighs 200 lbs. the mile; this process being completed, the core is again covered with a layer of felt, coiled in tanks under water, and subjected to tests as to its electrical condition before being, what is termed, "sheathed." As we have before remarked, it is the sheathing that gives the distinctive names to the cables, and it will be best, with the view of insuring a clear idea of the processes, to describe the four sheathings separately. There is first the outer covering for the "heavy shore-end cable," consisting of a serving of jute next to the core, a sheathing of "best best" drawn and galvanized iron wires, 0.160 in. diameter, weighing per nautical mile about 5,023 lbs., a serving of jute round the sheathing, a second sheathing of "best best" rolled and galvanized iron wires, 0.380 in. diameter, and finally an outer protection of two layers of bitumen compound, with two layers of jute between, laid on as follows: The first coating of the compound next the wires, then a serving of yarn, then a second coating of compound, and lastly a close serving of tarred yarn, laid in an opposite direction to the one previously laid on. The outer covering for the "ordinary shore-end cable" consists of a serving of jute next to the core, a sheathing of "best best" rolled and galvanized iron wires, 0.300 in. in diameter, weighing per nautical mile about 13,311 lbs., and finally an outer protection of two layers of bitumen compound, with two layers of jute between, laid on as before specified. The outer covering for the "intermediate cable" is composed of a serving of jute next to the core, a sheathing of "best best" drawn and galvanized iron wires, 0.160 in. diameter, weighing per nautical mile about 5,023 lbs., and the outer protection of two layers of bitumen compound and jute. The outer diameter of this cable is about 1.06 in., and its weight per nautical mile about 3 tons 2 cwt. The outer covering for the "main cable" is a serving of jute, next the core, a sheathing of "best best" drawn and galvanized iron wires, 0.095 in. diameter, and the outer protection of bitumen compound and jute. The outer diameter of this cable is about 0.86 in., the weight per nautical mile being about 1 ton 16½ cwt. Messrs. Siemens Bros. are able to sheathe the cable at the rate of 180 to 200 nautical miles per week.

The manufacture of the first section of the cable—that to be laid between Hong Kong and Shanghai—is now complete; it consists of 685 nautical miles of main cable, 272 miles of intermediate, 111 miles of ordinary shore end, and 30 miles of heavy shore end—in all, 1,098 nautical miles. Of this the following has been shipped on board the Tordenskjold: 50 miles of main cable, 4 miles of intermediate, 32 miles of ordinary shore end, and 10 miles of heavy shore end—a total of 96 nautical miles. The Great Northern will receive on board, into seven iron tanks, the following lengths of cable: 140 miles of main cable, 58 miles of intermediate, 70 miles of ordinary shore end, and 20 miles of heavy shore end, or 288 nautical miles in all. The Cella will take in after the Great Northern, and will receive 495 miles of main cable, 210 miles of intermediate and 9 miles of ordinary shore end—a total of 714 nautical miles.

We may mention, in conclusion, that the second section of this company's line—namely, that from Shanghai to Posiet Bay—is also in course of manufacture at Messrs. Siemens' works. This consists of 990 miles of main cable, 92 miles of intermediate, 96 miles of ordinary shore end, and 20 miles of heavy shore end, thus comprising an entire length of 1,198 nautical miles. The sheathing of 150 miles of this cable is complete.

The last girder of the Sutlej Bridge was hoisted on the 13th July, completing the communication between Lahore and Calcutta.

MANUFACTURE OF RUSSIA SHEET IRON.

From "The Bulletin of the American Iron and Steel Association."

Herbert Barry, Esq., late director of Estates and Ironworks of Vuicksa, thus describes the manufacture of sheet-iron in Russia :

"The refined iron is hammered under the tilt-hammer into narrow slabs, calculated to produce a sheet of finished iron two archimes by one (56 inches by 28 inches), weighing when finished from 6 to 12 lbs. These slabs are called *balvanky*. They are put in the reheating furnaces, heated to a red heat, and rolled down in three operations to something like a sheet, the rolls being screwed tighter as the surface gets thinner. This must be subsequently hammered to reduce its thickness and to receive the *glance*. A number of these sheets having been again heated to a red heat, have charcoal, pounded to as impalpable a powder as possible, shaken between them through the bottom of a linen bag. The pile then receiving covering and a bottom in shape of a sheet of thicker iron, is placed under a heavy hammer ; the bundle, grasped with tongs by two men, is pocked backward and forward by the gang, so that every part may be well hammered. So soon as the redness goes off, they are finished, so far as this part of the operation goes. So far they have received some of the *glance*, or necessary polish ; they are again heated, and treated differently in this respect, that instead of having the powdered charcoal strewed between them, each two red-hot sheets have a cold finished sheet put between them ; they are again hammered, and, after this process, are finished as far as thickness and glance goes.

"Thrown down separately to cool, they are taken to the shears, placed on a frame of the regulation size, and trimmed. Each sheet is then weighed, and after being thus assorted in weights, are finally sorted into first, second, and thirds, according to their *glance* and freedom from flaws and spots. A first class sheet must be like a mirror, without a spot upon it.

"One hundred poods of *balvanky* make 70 lbs. of finished sheets ; but this allowance for waste is far too large, and might easily be reduced. Four heats are required to finish.

"The general weight per sheet is from, 6 to 12 lbs. the larger demand being from 10 to 11 lbs. : but they are made weighing as much as 30 lbs. and may then almost be called thin boiler-plates, being used for stoves, etc. Besides the finished sheets, a quantity of what are called *red sheets* are made, which are not polished, and do not undergo the last operation.

"Taking the Michælofskoi Works, which are the largest sheet-iron ones in the empire, I found that the power running the sheet rolls was equivalent to 40 horses, the rolls making 70 to 80 revolutions a minute. The hammers used are powerful, having the surface of the stroke very large—just the contrary shape there to the ordinary tilt-hammer. A gang turns out in a shift from 450 to 500 sheets.

"In the central works, where they make sheet-iron from puddled iron, they *roll* it into the necessary size, and then roll this *balvanky* into half-ready sheets, with the same sort of rolls as are used in the North, but which however run much slower ; the finish being given also by hammers in the same manner, but leaving out the final part of the operation of placing cold finished sheets between the hot unfinished ones. The hammers are not so heavy, and the heating furnaces are not so well constructed and do not regulate the flame as well. The trimming, sorting, etc., is carried out in just the same way.

"The waste is really greater in the Central Works than it *should* be in the North, as the hammered iron does not leave such a raw edge as the puddled.

"A fact that proves the superior manufacture of the North over the north parts of the empire is, that whereas in the former sheet-iron is the best paying, in the latter it is the worst business.

"For the uses to which sheet-iron is put, ductibility is of the first consequence, and no sheet-iron is of passable quality that will not bend four times without breaking ; some made in the Oural I have bent as much as nine times without showing the break. Coupled with this quality, the glance must be taken into consideration, as good polished iron will not take so much paint as the inferior polished."

ON THE CHEMISTRY OF POTABLE WATERS.

By MR. RICHARD WEAVER, C. E.

From "The Builder."

It is not my intention to give an account of the functions performed by water as a physical agent; of the wonderful changes it has worked and is working upon the face of the globe; of its power as a transporting agent; nor, indeed, of the manifold purposes to which it is turned into usefulness by the ingenuity of human intellect. Yet, as a reservoir, as a store, as a source of power, I may just mention that we possess an immensity in our tidal rivers and around our coasts, which as yet is almost undreamed of in our philosophy; its magnitude is such that when viewed side by side with all the combined steam power of Britain, the latter appears insignificant and microscopic; and in the hands of a Wellington in science greater changes by far may be effected from this source than from the steam of Watt and of Stephenson. But I will lay before you some of the leading characteristics of water as employed for sanitary purposes, such as they occur to me; will point out their impurities, their source and mode of detection, examination, and possible estimation.

Passing over the modes in which chemists formerly examined water, I come to the

NITROGEN, CARBON, AND AMMONIA METHODS.

In the present day, I believe, there are only two methods of approximately determining the value of domestic water. The first is known as Frankland & Armstrong's gasometric system, and the second as Wanklyn, Chapman, & Miles Smith's ammonia system. Between each set of inventors there exists great rivalry, each insisting upon the accuracy of their system to the detriment of the other. Of this rivalry I will merely note my belief that, *theoretically*, Frankland's process is as perfect as any process is ever likely to approach; while, in practice, Wanklyn's ammonia method is much to be preferred. This being so, I shall give you a brief outline of the gasometric mode of Frankland, and then proceed to a more detailed and illustrated account of that of Wanklyn, premising that the results are such as I have myself personally obtained.

FRANKLAND AND ARMSTRONG'S GASOMETRIC PROCESS FOR THE ANALYSIS OF ORGANIC MATTER IN WATER.

These chemists endeavor to show, not the actual weight of organic matter present in a given bulk of water, but that of some of its constituents, and also some of the products of decomposed organic matter, which latter is termed by Frankland "the skeleton of sewage." First, the organic carbon and the organic nitrogen. These are converted into gas, and measured as carbonic acid and as nitric oxide. Second, the nitrates and nitrites; and, lastly, the ammonia. By this means the whole of the nitrogen contained in the water is valued, and a distinct estimate is made of the nitrogen rendered harmless by oxidation, and of that which yet exists as putrescible organic matter.

The first operation is to evaporate a known bulk of water to dryness with a prior addition of sulphurous acid, to expel all carbonic acid from carbonates, and also to destroy the nitrates and nitrites; the residue now contains the whole of the nitrogen of the organic matter and the nitrogen of the ammoniacal salts; and by making a separate estimation of the latter—through the Nessler test, to be hereafter described—and subtracting this from the total nitrogen obtained, we arrive at that corresponding to the organic nitrogen.

The process by which these determinations are made, somewhat resemble the combustions in organic analyses, but are much more complicated, and require greater delicacy of manipulation.

As an indication to the limits of this test, it is stated by Frankland that the $\frac{1}{85000}$ part of a grain of nitrogen and the $\frac{1}{1000000}$ part of a grain of carbon can with certainty be determined.

I shall not enlarge upon their mode of estimating the quantity of nitric acid; I have already indicated it is done as nitric oxide and the volume of gas measured off.

But I must draw your attention to a characteristic point in all the analyses of waters by Frankland, and notably indicated in the recent report of the Royal

Commission for Rivers Pollution, and in the examination of the metropolitan waters.

I refer to "the previous sewage contamination" column of such analyses. This question is a moot point with chemists, some considering it almost a worthless indication, and others insisting upon its great value in deciding the relative goodness or badness of potable water.

For my own part, I incline to think it as a somewhat vague term, and calculated to mislead the public, not as being worthless in its indications, but as really showing too little.

By the term "previous sewage contamination" would generally be implied the actual quantity of sewage with which a water was, or had been, contaminated at the period of its examination; but such is not the case, as I read Frankland's definition of the term, which, expressed in a few words, means the actual present amount of the *skeletons* of sewage,—of that which *was*, and has no reference to that which is at the present moment active and living sewage!

From which it follows that, probably, a water may contain variable quantities of sewage, and yet, according to the "sewage contamination" column of Frankland, no return would be made, and, by inference, that no sewage was present. That this is so, I may mention, a certain water was examined repeatedly by me, at intervals—which said water shall be nameless—and I always found indications of sewage matter; and, on turning for verification to Frankland's sewage contamination column, in his analysis of the same water, I found that *no* previous sewage was present. Now, this may be considered as either discouraging or encouraging, as viewed from opposite motives; and yet it is easily explained from the fact of my showing active and putrescent sewage, or analogous matter, whereas Frankland's column merely shows that which was ancient sewage, but is now no longer sewage. And for this, as one ground of objection, I must protest against the term, "previous sewage contamination," as being vague and delusive.

We now arrive at the method devised by Professors Wanklyn, Chapman, and Smith, for determining the organic matter in water by

THE AMMONIA SYSTEM.

Coupled with this, I shall introduce you, somewhat briefly, to a general system of water analysis, as suggested by these gentlemen, premising that much of it is obtained from older methods, now broken up and partly re-absorbed in modern systems. I divide the course into six divisions, as follows:—

1st. Hardness.
2nd. Chlorine.
3rd. Total residue and loss on ignition.
4th. Nitrates and nitrites.
5th. Ammonia.
6th. Organic matter.

HARDNESS.

The hardness of water has reference to its soap-destroying powers, and is caused by the oxides of calcium, magnesium, and iron, combining with the fatty acids of the soap forming insoluble salts; and so long as any of the earths remain in solution, the soap cannot exercise a detergent action; hence the value of soft water for cleansing purposes. This which I now hold before you is a solution of soap in aqueous spirits of wine, and is standardised by a somewhat tedious process to an equivalent of 16 grains of calcic carbonate per gallon of water; or, in other words, corresponds to 16 degrees of hardness, and with 1,000 grains of water of such hardness, 32 test measures, or 320 grains of soap solution, will just neutralize, and cause a lather to form, on thoroughly agitating, and will last about five minutes.

Upon such a water I now operate, and note the result.

CHLORINE.

The reason for determining chlorine in a potable water is that it points to a possible origin in sewage, for no sewage can exist in water without chlorides being present, sewage being rich in chlorine, especially from the urine. Yet, on the other hand, chlorine may very probably be present without any sewage, and it becomes a problem whether its source is due to sewage or to the geological character of the strata through which the water may have flowed.

The determination of the quantity of chlorine is very simple, and yet wonderfully accurate.

We first prepare a solution of argentic nitrate in pure distilled water, and to a

known strength. To the water under examination we add a few drops of neutral potassic chromate, and then the silver nitrate,—as in the experiment now before you—until a faint tinge of reddish colored silver chromate denotes the end of the chlorine reaction ; and from the amount of silver solution employed we estimate the chlorine.

TOTAL SOLID RESIDUE, ETC.

For this experiment it is essential that the quantity of water employed shall be very accurately measured, and that a delicate balance is at command, because each millegram—about $\frac{1}{65}$ part of a grain—of residue is equivalent to 1 grain per gallon of water.

The apparatus which is usually employed for the purpose of estimating the total solid matter contained in a water consists of a small copper or tinned vessel for generating steam. Through the mouth of the vessel passes a perforated cork, and again a large glass funnel ; into this latter is arranged an accurately weighed platinum dish. We now take 70 cubic centimeters of the water under examination, and place it in the platinum dish ; steam being generated in the lower apparatus, rises through the funnel, and, acting upon the platinum dish, the water contained therein is quickly evaporated—in fact, in practice, I find that about forty-five minutes are amply sufficient time for the purpose. The dish and its contents being now well dried and weighed, the excess of weight over the first weighing represents the amount of solid residue. If it is further desirable to ascertain the amount of loss on ignition, we carefully burn off all carbonaceous matter, at a faint red heat. Moisten with ammonia carbonate, well dry, re-weigh, and the difference represents the volatile matter. This process, as previously stated, is of very little value in estimating the character of water.

NITRATES AND NITRITES.

These are the skeletons of Frankland's sewage, and the mode by which their quantity is determined is exceedingly elegant.

We take a retort, and introduce 100 c. c. of water, to this add 60 c. c. of caustic soda solution free from nitrates, etc. The contents are now distilled until about 100 c. c. remain within the retort, and until the Nessler test is incapable of showing ammonia. Into the retort on cooling is added a small piece of the metal aluminium ; it is closed with a cork, through which passes a small tube in the manner I now show you ; it is filled with pieces of broken up tobacco-pipe, or analogous matter, and moistened with dilute chlorhydric acid. On standing for a few hours, the action is complete ; the whole of the nitrates have been resolved into ammonia, and the ammonia being distilled off, its quantity is determined by the Nessler test.

The process is so exceedingly delicate that it may be termed microscopic ; indeed, a very small fraction of a grain of nitrates per gallon being readily ascertained. As to the relative value of the nitrates in a water in determining its quality, there is much difference in opinion, some chemists allowing that considerable quantities may be permitted without detriment, whereas Frankland would probably condemn a water if even a gallon contained but half a grain of nitrates!

AMMONIA.

The estimation of ammonia in water may fairly be considered to belong to the domain of microscopic chemistry when the Nessler test is employed.

I will first describe this test. We dissolve 50 grammes of potassic iodide in a little hot distilled water, placing the dish in a water-bath, and adding a strong solution of bichloride of mercury. We continue the mercury solution until a point is reached at which the red precipitate formed no longer dissolves on agitation. We then filter, and to the filtrate add 150 grammes of solid caustic soda in aqueous solution, and then dilute the whole to the volume of 1 litre. A further addition of about 5 c. c. of mercuric chloride imparts sensitiveness. Allowing all sediment to settle, and pouring off the clear fluid, we have the Nessler reagent such as I now show to you.

If we take a water containing a trace of ammonia, and add the test, we obtain a yellowish brown coloration ; and according to the intensity of this color we calculate the amount of ammonia present.

We have now arrived at a stage in water analysis when we determine the presence of matters that are of prime importance in judging of quality ; that is, the

ammonia and the urea, and it is astonishing the minute difference in quantity which marks the point between waters that are foul and stinking, and waters that are good and wholesome.

THE ALBUMINOUS SUBSTANCES.

The most important of all the substances to be sought for in water intended for domestic purposes, is undoubtedly the nitrogenous organic or albuminous matter, and it is primarily by this test we judge of the antecedents of water, and the character and source of its contamination. It is simple and elegant.

To the remnants of the last experiment we add a strongly alkaline solution of potassic permanganate, and distil off not less than 200 c. c., and until Nessler ceases to show the presence of ammonia; for you must understand that the action of the permanganate is to cause most of the nitrogen from the organic nitrogenous matter—not nitrates—to be evolved as ammonia, and by estimating the quantity of this we have a fair idea of the quantity of organic matter on multiplying the result by ten.

The delicacy of these tests is truly wonderful, for we can directly estimate ammonia in water when its weight does not exceed the $\frac{1}{10000000}$ part of the water in which it is dissolved; and when we concentrate by evaporation or distillation, we increase its delicacy *at least* tenfold. We have now arrived at the end of our chemical examination of potable waters, and I will just add a few words as to the characteristics of really good water.

It should be clear, colorless, and transparent when viewed through a considerable stratum; it should be perfectly free from smell, both at the ordinary temperature and when heated to about 90 deg. Fahr. It is well also if a little lime or baryta water be added previously to warming; its hardness must not be excessive, and, above all other considerations, it must be free from sewage matter. This is of vital importance, for we have it on record for years past, and, in fact, there is not a summer or an autumn comes without hundreds of human beings that are carried away to an early grave from the use of water polluted with sewage; and excepting in the very vilest of waters, its presence cannot be detected excepting by competent chemical examination, for it is an ascertained fact that waters which are clear and fair to look upon, that are beautiful and sparkling to the eye, may, nevertheless, be veritable poison-cups.

Before closing, something will possibly be expected upon the second phase of water—that is, sewage. Much has been said and written upon this subject of late years; but very little has been accomplished towards solving the problem of what shall we do with our towns' sewage, as you are aware there are at this present moment three systems in vogue, viz:—

Deodorization with disinfection, of which the ferric chloride process is a type.

Secondly, the precipitation process, by which a portion of the mechanically-suspended matter in sewage is thrown down, of which the lime, the alum, the clay, and Sillar's processes may be given as types. In this class are attempted to be accomplished the objects of the first, and also to derive a profitable manure; and I scarcely need remind you that they generally fail in the first object, and some of them in the second.

Thirdly, deodorization disinfection, and a profit is endeavored to be attained by the irrigation of land with sewage. This is a very ancient mode; indeed, it appears to be coeval with man. Like every thing else, chemists and others differ as to whether this system of treatment is really efficient, some contending that the effluent water flowing from off the land, after its functions are here ended, is not in a much better condition than when it was turned on. Now, this objection seems to me, after some years' consideration of the subject, observation in various parts of the world, and a trifle of experiment, to be a very futile objection; for it is evident, upon reflection, that a sufficiency of filtration through, and not over, porous soil has not been attained; for, I take it, the absorbent power of soil will not be called in question, or what is the use of manure?—it must needs be washed away by the first smart shower. There are others—for example, the Rivers Pollution Commissioners—who contend, and I go with them a long way, that the water, as a rule, flows away remarkably pure, deprived of 90 per cent. of its impurities—the amount I give from memory—and this, you will understand, is in practice; but I go further, and contend that 99 per cent. should be removed, being, however,

fully aware that greater filtration is requisite,—not ordinary filtration, but that through land, nature's grand disinfectant.

There is, however, another objection to irrigation, viz., that a nuisance and probable danger are created by putting sewage upon land in the first instance; that is, the sewage being in an active stage of decomposition on arriving at the place of absorption by the soil, the gases of decomposition are diffused through the air at all points between the places of absorption and first contact with the open air. This I conceive to be a feasible objection, within certain limits, upon these grounds:—It is a condition of all matter to undergo decay and change through decomposition; it is thus with sewage, especially animal sewage,—a medium between that which was and that which will become life. Under certain conditions, especially of temperature, this decomposition is actively promoted; and I concede that from some causes—either of distance or of time—a sufficiency of decomposition may have been attained to create a nuisance and a danger at the points of distribution of the sewage in question. Now, this is a condition I have long foreseen may probably arise, and have from some attention and a little experiment endeavored to contribute my mite towards the knowledge tending to a solution of the problem.

I need not give you any details of all the schemes that entered my mind and were developed by experiment; suffice it that that which I found the most successful was chlorine, another was oxygen, but I will now only trouble you with the former. This from limited experiment I find to answer the required purpose; it acts instantly upon the organic matter of sewage; upon that in a putrescent state, the gases are fixed or decomposed, ammoniacal salts are secured in the water, deodorization and disinfection are so effected that after a lapse of even weeks not a trace of unpleasant odor is perceived, and when this sewage is freed from suspended matter you cannot from mere external evidence tell it from the finest potable water.

The process I propose is something after this manner: chlorine to be generated by the perpetual regeneration scheme of Walter Weldon, in which chlorine is obtained from chlorhydric acid through the agency of manganic oxide, the same oxide being used over and over again for hundreds of times; so that the expense is reduced to that of the chlorhydric acid, the labor, and wear and tear of plant; and you are aware this acid is cheap enough, being a waste product of the alkali works, and can be purchased in a concentrated state at 40s. or 50s. per ton,—a sufficiency, I believe, to treat millions of gallons of sewage.

I shall now conclude this exhaustive lecture,—that is, exhaustive of your patience and good nature—not the subjects, for of these it is a mere outline—and give you some idea of the value of sewage, from a calculation I made recently, based upon an average of fifty samples of Leicester sewage. The value of the ammonia alone in a year's flow, if placed upon the market and sold at current rates, would realize very nearly £40,000; and this substance, although by far the most valuable constituent, is not the only one, for we have the phosphates and the alkalies, and others; and you will agree with me that there could be no honor too great for the State to confer upon that man who shall effectually solve this problem of utilization of waste, although I do not believe it will ever fall to the lot of any individual to achieve undivided success, but will rather burst forth spontaneously from many minds, and will attain success, as have all the great events of modern days,—like our railways, our steamers, and our electricity.

Russian papers lately received publish the text of a convention which has just been concluded between the Russian and Austrian Governments for the union of the Kieff-Odessa Railway with that of Leopol-Vienna *via* Volotchisk and Tarnopol. It is provided that the gauge shall be different, as in the case of the Russo-Prussian lines, so that the Austrian carriages will not be able to pass into Russia, nor Russian into Austria.

The preliminary arrangements for the construction of the International Bridge at Buffalo are now being carried out, and it is understood that proposals will shortly be made for raising the necessary capital, $1,000,000, by bonds to be issued in England.

ON THE ESTIMATION OF MANGANESE IN SPIEGELEISEN AND FERRO-MANGANESE.

By THOMAS ROWAN, F. C. S.

From "Engineering."

The following process for the determination of manganese is, I need hardly say, not novel; but having had occasion to make many estimations of manganese in spiegeleisen and ferro-manganese, I can recommend it as superior for speed and accuracy, where manganese in quantity has to be determined, to the other processes commonly resorted to.

A convenient quantity of the sample, say 20 grains, in as fine a state of division as possible, is digested in a long-necked flask with about 1½ oz. of hydrochloric acid until complete solution is effected. The solution is then oxidized with chlorate of potash (K O, C O_5, or K C O_3) added from time to time, and finally boiled until traces of chlorine can no longer be detected.

The solution is now saturated by liquid carbonate of soda (Na O, C O_2, or Na_2, CO_3) added in small successive quantities, the flask being well agitated after each addition of the alkali. On nearing the point of saturation each addition of the carbonate of soda occasions the separation of small quantities of carbonate of iron and manganese, which disappear on the flask being shaken. When this is observed the alkali must be added with extreme caution, but the deep blood-red color now acquired by the solution will, after a little practice, be a sufficient indication to the operator that the desired point of saturation or neutralization has been attained. Or, if it is preferred, the smallest excess of carbonate of soda may be added, and the permanent precipitate which forms, re-dissolved by the cautious addition of hydrochloric acid introduced drop by drop.

Before treating with carbonate of soda, the solution should be evaporated to as small a bulk as possible, the presence of much free acid causing the expenditure of an unnecessary amount of alkali, and the violent effervescence caused by the escaping carbonic acid, often entails loss by the projections of portions of the solution from the flask.

From 6 to 8 oz. of water are now added and the iron precipitated as the basic acetate of iron by the addition of a concentrated solution of acetate of soda (NaO, C_4 H_3 O_3, or Na, C_3 H_2 O_2). If the solution has previously been successfully neutralized with carbonate of soda, the ferric acetate will at once make its appearance, but if that point has not been reached the iron will only precipitate after boiling, and then not completely, and the precipitate will be found to be so gelatinous as to cause much trouble by clogging the filter.

After the addition of the acetate of soda, the flask and contents are briskly boiled for about twenty minutes, and then allowed to repose for a few minutes, that the acetate of iron may settle to the bottom of the flask, when the solution is carefully decanted from it on a filter. More water is then added to the flask with a few drops of acetate of soda, boiled for 5 or 6 minutes and again decanted from the precipitate. This is repeated a third time. The acetate of iron can then be thrown on the filter and washed with boiling water. The filtrate, with washings, is removed to a beaker and brought to a temperature of about 100 deg. Fahr., and a stream of chlorine gas passed through until a faint smell of that gas can be detected from the liquid. This is ascertained by stopping from time to time the passage of the chlorine, blowing from the surface of the liquid in the beaker the gas that may have lodged there and then testing the smell. If chlorine can be detected the addition of the gas is finally discontinued. The beaker is now carefully covered and set aside in a moderately warm place for six hours. The precipitated binoxide of manganese (Mn O_2 or Mn_2 O_2) is removed by filtration, and chlorine is again passed through the filtrate to ascertain whether all the manganese has been removed. When the precipitated manganese settles to the bottom of the beaker, if the liquid above is purple-colored it indicates that an excess of chlorine has been used, and that permanganic acid has been formed. This is easily remedied, as the permanganic acid is at once reduced to the binoxide by the presence of any organic matter. A few

drops of alcohol may be added, and the precipitated binoxide of manganese filtered off.

The precipitated binoxide of manganese is redissolved by pouring hot dilute hydrochloric acid on the filter. The manganese is reprecipitated as carbonate by a solution of carbonate of soda, and boiled well to expel all carbonic acid, the carbonate of manganese being slightly soluble in carbonic acid. The carbonate of manganese is then collected on a filter, washed well with boiling water, dried, ignited, and weighed as the red oxide $Mn_3 O_4$.

The binoxide of manganese has such a tendency to appropriate alkali that it cannot be directly ignited to the red oxide. When this is done without redissolving and reprecipitating as carbonate, I have found that one part of the ignited precipitate contains 0.0842 of alkali, which must be deducted from the weight before calculating the percentage of metallic manganese.

If the weight of the ignited red oxide thus obtained be 3 gr., the following calculation is made :

Wt. of red oxide ppt.

$$1 : 0.0842 :: 3 : 2.7474.$$

In a rigorous analysis, however, it will be found more satisfactory to proceed as directed above, viz.: redissolve the binoxide of manganese first obtained, and reprecipitate as carbonate before proceeding to ignite, and weigh. The amount of metallic manganese is readily ascertained from the weight of the ignited red oxide, 100 parts of which contain 72.05 parts of metallic manganese.

ON THE RELATIVE SAFETY OF DIFFERENT MODES OF WORKING COAL.

From "The Mining Journal."

It was maintained by the author that whilst there was no possibility of freeing the workmen engaged in coal mining from accident, there was reason to hope for a considerable diminution in the proportion of those killed to the number employed. It was the purport of this communication to show that the mode of getting coal had considerable effect on the safety of the workmen. The accidents incidental to mining were classified by Her Majesty's Inspectors of Coal Mines under five heads, as arising from explosions, from falls of roof or of coal, in shafts, from miscellaneous causes underground, and on the surface. It appeared that in the years 1866, 1867, and 1868, out of a total of 3,686 casualties, 1,091 were the result of explosions, and 1,255 of falls, or, respectively, 29 per cent. and 34 per cent. of the whole ; the remaining 37 per cent. being attributable to other causes, which were not influenced by the mode of working. The different methods of getting coal, which were described in detail, were the practical application of two distinct principles. One idea was, to remove the coal at two operations, and this was practised in the bord and pillar work of the North of England, in the bank work of Yorkshire, and in the stall work of South Wales. The other idea was, to remove the whole of the mineral at one operation, as exemplified in the long wall system of the Midland Counties. In the latter case, as the faces advanced, packwalls of roof rock, or bind, were built at regular intervals, and, whenever a sufficient width of opening was obtained, the roof settled down, with or without fracture, upon these packs. Accidents by falls might fairly be brought to the test of figures, for, although the roofs of various seams might differ much, the averages of large districts were likely to be uniform. Of a gross tonnage of 198,636,043 tons obtained by pillar work in 1866, 1867, and 1868, the casualties by falls were 814, or 231,739 tons of coal for each life. Of a gross tonnage of 22,899,000 tons extracted by the long wall plan the casualties were 75, or one life for every 305,320 tons. If the latter ratio existed in pillar work the casualties would have been reduced from 814 to 614, or a saving of 200 lives. In these calculations certain coal fields, which yielded about three-tenths of the produce of the whole kingdom, had been excluded ; as in North Staffordshire, Cheshire, and Shropshire both modes of working coal were adopted, and the same was the case in Scotland. The mortality from falls was greatest in

South Staffordshire, where the lofty cavernous openings killed off one man for every 214,517 tons of coal raised, or an excess over the ratio of 35 per annum. There, too, the coal was obtained by both methods, but the greatest number of accidents took place in the Thick seam, which was worked in pillars. The greater safety of long wall mines from falls was owing to the narrow width of the working places, to the constant change to a new roof, so that there was not time for atmospheric action, which greatly weakened the roofs of many mines, and to the small extent of open mines, which permitted a more thorough examination. It might be thought that in long wall work the constant settlement, or bending down, of the roof would be attended with danger, but practically that was not the case. If a fracture occurred, it was not by the running down of a number of loose fragments, but a general settlement took place gradually, accompanied with so much noise that warning was given, when the workmen retired. The excessive mortality of some pillar districts was owing to the weak, under-sized pillars, which were crushed and sank into the floor, and induced a weak, jointy state of the roof. The goodness of a roof as often depended upon the way in which it was managed as upon the character of the material of which it was composed.

With respect to explosions, the author contended that the mode of getting coal had more influence on this question than was usually allowed ; and whilst fans, safety-lamps, the absence of gunpowder, and all sorts of precautionary expedients were proposed, and were more or less adopted, the effect of the mode of working, perhaps the most important of all, had been lost sight of. It might be safely laid down that that mode of working was the safest from explosions which admitted of the most perfect ventilation, which was the least subject to a local failure of ventilation, in which the discharge of gas was best regulated, in which large accumulations of gas were prevented, and in which the superintendence of the workmen could be most thorough. In an unbroken coal field the free hydrogen might be assumed to be distributed evenly over small areas, and each ton of coal would have a certain proportion diffused through it. If this were liberated only in the coal actually cut, and when it was cut, the amount of ventilation could be exactly regulated to the production of the mine ; and the mode of work, so long as ventilation was possible at all, would be immaterial. The fire-damp lying in coal seams possessed considerable mobility amongst the particles of coal, and, as it was often at a pressure in excess of the atmosphere, it travelled through the coal for some distance towards a point of discharge. The rapidity with which a given area was so drained, no doubt, varied in some proportion to the difference between the initial pressure of the gas and that of the atmosphere, and the amount of resistance which the gas met in permeating the coal. It also varied according as the openings were bordways or endways of the seam. In all probability it was three or four times the greatest on the end of the coal, as the cleavage planes were, to a certain extent, channels for the passage of the gas. Thus, in a headway on the end of the coal, the discharge of gas was most abundant at the back of the heading ; while in bordways it was most perceptible at the sides of the heading, and in such a heading a large part of the gas would probably be let off for some yards on each side. When the excess of pressure was relieved the discharge might be supposed to vary with the changes in the barometrical pressure. It was suggested that experiments should be made in different localities, to ascertain (1) the quantity of gas given off per sq. yard of freshly cut surface, (2) to what extent this varied on the face or end, (3) in what ratio this discharge diminished with time of exposure, (4) to what extent barometrical changes affected the discharge of gas, and (5) by what amount the pressure of gas increased, as measured from the exposed surface inwards to the solid seam. It was believed such experiments would show that from 50 per cent. to 75 per cent. of the gas contained in the coal lying 10, 20, and 30 yards on each side of a bordways heading was liberated when, and after, this was driven.

As the free hydrogen gas came not only from the hewn coal, but also from the solid seam, it was important that the surface exposed to the air should be as small as possible. It was argued that every mode of pillar work liberated 3, 5, or 10 times the amount of gas per ton hewn in

the solid than was liberated by a system of long wall work. If, therefore, the diluting power of the air-current was the same in both cases, 3, 5, or 10 times more would be necessary in pillar mines than in long wall mines. In a mine under the author's charge this excessive discharge of gas in pillar roads was very noticeable. Long after a headway was driven the gas oozed out of the sides of the headway, and might be heard at a considerable distance. In the long wall faces this was not perceptible, as the gas given off there was that due merely to the coal hewn.

Again, in pillar mines from 6 to 20 times as much surface of coal was exposed as in long wall mines, and, therefore, such mines were from 6 to 20 times more subject to the effect of changes in the atmospherical pressure.

On inspecting the maps of mines worked by different pillar methods, and comparing them with the diagram showing a like extraction of coal by long wall, it was clear how large a proportion the gas discharged in the former must bear to that in the latter. It was frequently argued that this gas drainage was desirable, but it was submitted that before such a course could be with propriety recommended it was necessary to show that the ventilating current would be proportional to the discharge.

The ease with which a mine could be ventilated, and the freedom from local derangement, would depend much upon the cubic contents of open mine, upon the freedom from stoppings, doors, etc., and upon the general simplicity of the arrangements. For a like extraction of coal the cubic contents of pillar mines were from 10 to 20 times the amount of properly designed long wall mines, and the drawings showed clearly the relative simplicity of each. In every pillar mine the workings were driven in advance of the ventilating channels, and constant brattices were essential. It would be seen, by examining the reports, how numerous were the accidents from defective brattices.

In South Wales the working places were driven into the solid coal, and when finished had no channel left for a steady through current, and thus the chance of their harboring fire-damp was very great. In the north of England there were none of these dumb points, but the cubic contents of bords, in which there was no sensible current, was often very large. Whatever might be the difference of opinion with regard to barometrical changes in mines, it was reasonable to suppose that they would exert the least influence where the surface of coal which might exude gas was the least. The proportion which the surface exposed in pillar mines bore to that in long wall mines was from 10-20 to 1. The goaf of a long wall mine became approximately solid as the coal was extracted over large areas, and thus permitted of a general settlement. In pillar mines the tendency was towards the formation of many small goaves, where there could be no surface settlement. These goaves thus became so many gas holders. The long wall mode of work also admitted of the nearest approximation to goaf ventilation. The only open parts were the edges, and as these were cut through with roads a constant current could be maintained along them. It was possible, in a properly laid out long mine wall, to keep the goaf clear of gas as far back as it was open. In pillar workings there was no possibility of sending air into the goaf, and it thus became charged with gas. It was, therefore, submitted that the safety of mining operations might be increased by the extension of long wall working. It was satisfactory to be able to add that on economical grounds it was daily gaining in favor, and that simplicity, compactness, small cubic contents of open mine, small exposure of coal surface, regular gas discharge, and thorough ventilation, could be best attained in long wall mines.

ENGLAND has 500 blast furnaces, which every year reduce 12,000,000 tons of ore to 4,800,000 tons of metal, and which consume 14,000,000 tons of coal. The manufactured metal is worth about $60,000,000.

THE bridge over the Dee, forming part of the viaduct which supports the Chester and Holyhead line, is about to be entirely re-constructed.

THE railway bridge lately erected over the Dnieper, near Kiew, is the largest work of the kind in Europe, being 3,503 ft. in length.

AN ARCHITECT'S ACCOUNT OF THE GIANT'S CAUSEWAY.

From "The Builder."

The curious and wonderful assemblage of basaltic pillars on the coast of the county of Antrim, Ireland, known as the "Giant's Causeway," has been a thousand times described by artist, essayist, journalist, traveller, and poet. It has been a meet subject for the whole artistic and literary phalanx of Europe and America. Topographers have rounded it, geologists hammered it, painters limned it, poets apostrophized it, and Vandal excursionists bid fair, if not stopped for the next generation, to trample it down to the sea level, or pick it to pieces, to satisfy an uncontrollable and unwholesome passion for carrying home "a bit of the Giant's Causeway," to ornament their chimney-boards. Amongst all the sight-seers who visited the Causeway, we have never known but one architect who visited it that described it. As this architect's account has not met the eyes of many, and as it is to our thinking one of the most interesting descriptions that have been given, we will present it to the readers of the "Builder." Though written many years ago, it has lost nothing of its interest. The writer was an architect of eminence in the sister kingdom, who held during his lifetime a conspicuous place in his profession, and lived to find a successful rival in the person of his own son. R. Morrison, architect, for he was the writer, enjoyed good practice in Ireland. One of the name in the sister island has impressed his character, as our readers know, upon his works.

Our architect thus describes the Giant's Causeway :—"The sea cliffs contiguous to the Causeway are particularly high. You approach it by a narrow path, or a long dreary precipice almost impassable. Every image which presents itself has something uncommonly grand and magnificent. Above you, the impending rocks to a timorous fancy threaten instant ruin; around you the sea presents immensity, unless where the shore of Scotland gives the idea of a world set at a proper distance for contemplation ; and below you the dreadful precipice produces an effect of inexpressible solemnity.

"The Causeway is a low head, extending from the head of the cliffs into the sea like a mole, consisting of a great number of polygonal cylinders or pillars, so closely united that the edge of a knife cannot be inserted between their adjacent sides. At the first view this head did not appear to me so grand as I expected from the drawings I had seen of it ; but when I came to walk on it, and to consider its plan and situation more attentively, it appeared a stupendous production of nature, extending from the bottom of the cliffs into the sea, but to what distance has never been ascertained. At low water the length of it appears to be 600 ft. ; its breadth in one place, 240 ft., in the narrowest, 120 ft. ; it is very unequal likewise in its height. In some places it is 36 ft. high from the level of the strand, and only 15 ft. in other places. The pillars of which the Causeway is formed stand most of them perpendicular to the plane of the horizon, yet the contexture of them is so adapted that there is no vacuity between them. I could not discern whether they run underground like a quarry or not. Some of them are very long, others short, and some for a large space are broken off at an unequal height, so that their tops make an even plane surface. Many of them are imperfect, crooked and irregular; others entire, uniform, and handsome, and these of different shapes and sizes.

"I found them almost pentagonal or hexagonal, a few excepted, of seven sides, and many more pentagons than hexagons; but they were all irregular, for none that I could observe had their sides of equal breadth. These pillars are some of them 15 in. and some 18 in., and some of them 2 ft. diameter. None of them are one entire stone, but every pillar consists of several joints or pieces, as I may call them, and the whole are jointed as close as it is possible for one stone to lie upon another, not jointing with plain flat surfaces. The upper ends of most of the pieces are concave, the lower ends convex, the prominences of which are nearly quarters of spheres, with rims round them. The length of each of these pieces which compose the pillars is 6 in., some 12 in., 18 in., and 2 ft., and easily separated, though so united in all appearance. When I parted them asunder, both the concave

and convex superficies appeared very smooth, as are also the sides of the pillars which touch one another, being of a whitish freestone color, but of a much finer and closer grit. When I broke some pieces of them, the inside appeared like blackish iron gray, somewhat like the best limestone marble before it is polished, but of an extraordinary hard, close and compact texture—their grit or grain so very even and fine that it hardly appears; but, where the stone is nearly broken, there it shows itself on its surface like a very minute, small glistening sand, thickly interspersed with the rest of the solid, and this (by reason of its parts being so closely combined together) has more specific gravity than most other kinds of stone. I must observe that, in my opinion, the curiosity of this place is much increased by the stones of which the pillars are composed being the irregular rather than the regular figures of geometry, as it is much more difficult to suit the sides of polygons together than squares and triangles, the latter being done easily by putting together two triangles equal to the square. I perceive in some of the stones the scheme of the 11th, 12th, 13th, 14th, and 15th propositions of the Fourth Book of Euclid, wherein an ordinate pentagon was inscribed; about it was circumscribed a circle; in another I observed a cylinder circumscribed about a cone. There is nothing more surprising than the piles of rocks here composed of a vast number of polygons; the external angles of each exactly suiting that made by the adjacent figures, and some rising like a flight of stairs to a considerable height.

"At a small distance from the Causeway you discover in the impending cliff to the south-east, one large pile of those polygonal figures, so situated and united as to appear really to be what it is commonly called the Giant's Loom or Organ, as in perspective it resembles either. Another on the summit of the precipice has so much the resemblance of the chimneys of a house that the Laia, some ship of the Invincible Armada, mistaking it for a town, in the approach to it split on the rocks.

"From observing at low water the rocks stretching a great length into the sea, and that there are similar ones on the opposite coast of Scotland, some have been led absurdly to imagine that there was formerly a design of uniting the kingdom by means of this Causeway!—a notion pregnant with folly. Others, from observing rocks in the precipice or cliff similar to those of the Causeway, have imagined that the sea, by undermining, has brought down these; but there is really no foundation for the remark, there not being any great similarity between the stone in the Causeway and the precipice; and the pavement of the Causeway extends along the shore, where it could not have fallen from the precipice; nor can we, with any degree of reason, attribute to a chance fall a phenomenon so regular, so perfectly connected, and so extensive. Others, again, with a superior display of penetration, endeavor to account for the figures of the stone from the crystallization of salts. This they found, I suppose, on the doctrine of l'Abbé Nollet, who, in his lectures on experimental philosophy, says that 'every salt when crystallized generally affects a figure which is proper to itself, and which probably depends on the figures belonging to its smallest part. Sea salt, for example, forms amber, saltpetre needles, sugar globules,' etc.

"For my own part, I think it most reasonable to imagine that nature, which pursues infinite diversity of plans, forming some things for the use, others for the pleasure, of mankind, has left this and such like curiosities as perpetual subjects for our admiration, that, from observing the wonders of the visible creation, we might be led to the sublime contemplation of the invisible Creator, and, as Democritus philosophized amongst the rocks of Abdera, were a man of reflection to confine his whole observation to this Causeway, and attentively to consider it, he would find himself surrounded by pregnant proofs of the divine wisdom and power. Indeed, all the works of human art must cease to attract if compared with this. Not the army of Xerxes, with an Archimedes to direct them, could form anything so wonderfully great, so uniformly various.

"The usual attempts to explain this phenomenon appear to me very absurd. It had its name from the ignorant credulity of the unlettered, and superstitious vulgar causes, often of more absurd errors."

So ends the description given by an architect of a visit to the Giant's Causeway.

NAVAL ORDNANCE.

From "The Engineer."

Our heavy ordnance is not what it ought to be. If it were we should not hear so many stories of the breaking up of shot and the premature bursting of shell. But why is it not what it ought to be? Where does the defect lie? In the rifling, undoubtedly; not in the gun. Our readers will remember that the result, if not the logical consequences, of the celebrated 7 in. gun competition, was the introduction into the service of the French rifling and a studded projectile. The principle of the Fraser gun is, of course, as we have always maintained, excellent. We complain now, as we have done before, that our heavy guns are not perfectly satisfactory, because the chief feature of the rifling at present in use is a gaining twist, and the chief feature of the projectile a number of holes in its sides. We do not hesitate to say that these are two radical defects, either of which would suffice to vitiate the system; the combination of the two leaves no room for surprise at the disasters which have already occurred, or at any which may occur in future. The rifling is that which throws the greatest strain on the projectile, and is least able to bear a strain itself; the projectile is that which is least capable of enduring any jar, and is best calculated to inflict a series of jars upon itself and upon the rifling. Never before was infirmity so well or so ill mated with infirmity. If, however, we were asked to pronounce which of the two evils, considered separately, is the greater, we should certainly decide for the projectile. Hardened at its point by a chill, and weakened in its sides by huge stud-holes, it seems to be always in antagonism to the objects of its own existence. We can see that every resource has been exhausted in the attempt to strengthen the metal, and we have not a word to say against any efforts in that direction. But the harder the metal is made the less ought its powers of coherence to be diminished afterwards. When we buy a sheet of postage-stamps we thoroughly understand the perforations to be made in order that each stamp may be easily detached from its neighbor; and all analogy would lead us to infer that when we find a similar arrangement elsewhere, it is made for a similar purpose. A glance at the projectile, bored for the insertion of the studs, or after the studs have been displaced by firing, at once suggests the idea of the perforated sheet of stamps. The fragments into which the shells are frequently broken carry out the simile only too well. It was a most unfortunate circumstance, as we pointed out at the time, that the committe appointed to decide upon the merits of the 7 in. guns was composed almost exclusively of military men. There were two elements almost entirely wanting—the practical knowledge of the sailor, and the skill of the mechanical engineer. The latter is required for a just decision upon all gunnery questions, and no one, however great his experience as an artilleryman, can know what are the exigencies of naval warfare, or what is required in a gun for naval service, unless he has had the training of a naval officer. It is for this reason that the Woolwich gun and the Woolwich projectile have exhibited their defects most conspicuously in those qualities which are most required at sea. Thus the weakness of the studded shell does not proclaim itself so manifestly when the projectile strikes the target directly as when it strikes obliquely. When fired at a Shoeburyness target, the line being almost direct, the shell generally penetrates tolerably well. But when the armor plate is set up at an inclination or angle to the line of fire, the shell no longer has the power invariably to force its way through, but often breaks into two or more pieces at the moment of contact, if it has not been previously broken in the gun. This is not the fault of the gun, nor of the shape of the projectiles, but simply of the system of rifling, which weakens the metal, while failing to insure a perfectly true axial rotation of the shot or shell. At sea it very rarely happens that the target—the side of an armor-plated ship—can be struck directly, so that the shell, if effective at all, is effective only under conditions which could not be secured in actual naval warfare. The combination of the gaining twist with the studded projectile introduces so many elements of weakness that

the spiral cannot be made sharp enough to give the shell sufficient rotation. The projectile, consequently, even when it does not break, enters the target with an uncertain, unsteady motion, which renders it very deficient in penetrating power, and this is especially the case with the heaviest guns. As a remedy for this evil, it has become the custom to fire chilled shot, instead of shell, at an obliquely placed target; and as the shot is of a somewhat different form, with its centre of gravity thrown further forward, the results attained by it have been better than those attained by the shell. But this partial success is gained only by the abandonment of the most successful instrument of naval warfare. No one who has a competent knowledge of the subject can doubt that we should in every case aim, not at the substitution of shot for shell, but at the substitution of shell for shot.

Five years have now elapsed since the 7 in. gun competition to which we have frequently referred, and it is clear that any improvements in the minor details of our ordnance could by this time have been effected, and that continued failure can be due only to some radical defect in the system. It may be said that there is nothing easier than the task of the critic who lays bare a fault but cannot suggest a remedy. To this we answer not only that we have already pointed out the remedy, but that a preventive was in the hands of the committee when the rival systems were submitted to them. Having to choose between a plan at once sound and economical and a plan at once unsound and expensive, they deliberately preferred the latter to the former, though they appropriate some of the ideas of an unsuccessful competitor. The remedy was the Scott system of rifling ordnance. In this, it will be remembered, there are three leading characteristics. These are an even, instead of a gaining, twist in the rifling, a peculiar groove, invented by Captain Scott, narrow, shallow, rounded, deeper on the bearing than on the loading side, and a projectile with iron flanges cast in one with itself. The principle of centring the shot in the gun, it is well known, was originally pointed out and applied by Captain Scott, and we are not aware that it has been anywhere so well put in practice as in Captain Scott's own system.* It was he who first suggested that there should be less windage over the bearing part of the projectile than over its body, so as to keep the body of the shot from contact with the bore of the gun; and this, in combination with his peculiar groove, has the effect of carrying the shot and shell with a steady motion through the centre of the gun, with the gas equally distributed above and below. Accuracy in shooting is necessarily increased by this device, and a greater range is attained at all elevations. The trajectory of the ribbed projectile fired from the Scott gun is low, its initial velocity high, its steadiness and penetrating power very great. The iron flanges have an effect directly the reverse of the stud-holes adopted in the Woolwich system. They give strength instead of weakness to the projectile, and preserve, instead of injuring, the rifling. They run no danger of breaking up, either within the gun or on their first impact upon the target; above all, they are specially adapted for use as shells. The fact that the missiles are cast whole, with buttresses, so to speak, upon their outer walls, not only renders them secure from fracture, when made of the service thickness, but would bestow upon them the same immunity when made much thinner, and, therefore, gives a far greater powder capacity than that of the Woolwich projectile. We have from the first pointed out that in the 7 in. gun competition the balance of advantages lay with one gun. We now maintain that with every increase in the weight of our guns and projectiles, the balance in its favor is increasing. Had the ribbed projectile system been adopted from the first, we should, in all probabilty, not have heard of guns disabled by their own projectiles, of shells turning over and over in the air, of contrivances to save ships and crews from the dangers of their own guns. All these disasters show that there is something radically wrong, which no trifling change of detail can set right. The first cost of the projectiles is enormous; both projectiles and guns seem to delight in adding to the expense by a process of mutual destruction. It is high time that something were done to curtail this reckless outlay. We do not pretend to be omniscient, or to predict what will be the

* See Holley's text-book on "Ordnance and Armor."

cheapest gun of the next century, but we do know that the Woolwich system of ordnance is neither the best nor the cheapest which can be adopted. In our impression of January 11, 1867, we gave a table showing the comparative merits and cost of the Scott gun and its rival. We will only add that the disparity between the two would be greatly increased in the 25-ton gun. In rifling the Woolwich gun, the cost per groove is £1 16s.; in the Scott gun the cost per groove is only 17s.; and we believe fewer grooves would be required in the Scott than in the Woolwich gun. Even for the 7 in. gun, the cost of the Scott shell was £68 per thousand less than that of the Woolwich or French shell, and the cost of the Scott shot £83 per thousand less than that of the Woolwich or French shot. The expense of the stud system is in itself so great, and the number of studs required for the heavy projectiles so large, that the economy effected by the ribbed system would be far greater than is apparent from these figures. On every ground, then, we hope the time is not far distant when a new trial will be made. We ask no more, and we will be satisfied with nothing less. We are very far from advocating the immediate adoption of the Scott gun into the service without further question; but we do assert that the existing system of rifling having, as we predicted it would, proved a failure, the Scott system should now have that further trial to which it has long since proved itself to be entitled.

Apart from the question of economy, the subject is one of the greatest national importance. Our prestige is at stake in more ways than one. Not only have we to maintain our supremacy at sea, but it is also most essential that we would not lose our reputation abroad as naval engineers. It happens unfortunately that the mishaps which have occurred through the adoption of the gaining twist and the stud-shot have been repeated in the Italian navy, in which our system has been copied. Foreign nations are already learning to build their own ships; a few more lessons like that which the Italians have just learned will do irreparable mischief both to our trade abroad and to our own confidence in our resources. England cannot afford to have it said that she does not understand the principles of modern naval warfare; and we trust we shall ere long see the introduction of some plan which shall be correct in theory and effective in practice.

We hope the warnings of past experience will not be forgotten, and that when a new committee is appointed the military element will be properly balanced, both by naval officers who have a special knowledge of the subject, and by some of the ablest of our civil engineers.

ON COAL MINING IN DEEP WORKINGS.

From "The Mining Journal."

In this communication the principal conclusions arrived at were:—

Judging from the statistics of the past few years, the production of the British coal fields could not be considered to increase annually in a constantly increasing ratio, as had been surmised, but might be estimated at an average output of 105 millions of tons yearly. Estimating the coal remaining in the British Islands to a depth of 4,000 ft. to be 37,300 millions of tons, this quantity of coal would supply the annual demand of 105 millions for 355 years; and, taking the limit to deep mining to be a depth from the surface of 7,000 ft., the further quantity of coal estimated to be workable to this depth was 57,222 millions of tons, which would extend the supply for a further period of 535 years. The chief localities in the British Islands where coal would probably be found at greater depths than had hitherto been reached were (1) the West Coast of Ayrshire (2), the West of Lancashire (3), the East of Yorkshire, Derbyshire, Nottinghamshire and Staffordshire, and (4) below the seams worked at present in the South Wales basin.

Deep mining had been carried on much more extensively in Belgium than in England, there being only 12 pits of a greater depth than 1,500 ft. in the latter country, as compared with 68 in the former. The deepest coal mine in the

world was probably that of Simon Lambert, in Belgium, which had attained the great depth of 3,489 ft. The deepest coal mine in England was the Rosebridge Colliery, in Lancashire, which had reached a depth of 2,418 ft., the temperature of the coal at that depth being 93.5 deg. The distance from the surface of the ground to the stratum of invariable temperature might be taken at 60 ft., and the constant temperature at that depth at 50 deg. The accounts published between 1809 and 1840 of several hundred experiments relating to the temperature of coal and metalliferous mines showed the increase of temperature to vary from 1 deg. for every 45 ft. to 1 deg. for every 69 ft.; the distance from the surface at which the experiments were made varying from 100 to 1,700 ft. The results of more recent experiments in England and on the Continent were irregular, and showed an increase varying from 1 deg. for every 41 ft. to 78 ft. the distances from the surface being from 700 to 2,600 ft. On comparing the experiments made at the two deepest English mines—Rosebridge and Dukinfield—it was found that the increase of temperature due to depth was mu h less rapid at the latter colliery than at the former; and this difference was assumed in a paper read recently by Mr. Hull, to be due to an amount of heat being lost at Dukinfield, owing to the heavy inclination of the strata, which was about 1 in 3, whilst at Rosebridge the coal seam was nearly level. The relation of the position of the bottom of a mine to a sea level influenced the temperature, as shown in accompanying tables. In one table the average increase of the temperature of 3 mines of a high elevation was 1 deg. for every 71.6 ft., whilst the increase for 3 mines at some distance below the level of the sea was 1 deg. for every 62.3 ft.

The experiments relating to the underground temperature of the air at the Rosebridge Colliery showed an increase in the temperature of the air in passing from the downcast to the upcast shaft of from 55 deg. to 63 deg.; the air passing through workings the temperature of which was 78 deg., and the normal temperature of the coal being 93.5 deg. The experiments at Monkwearmouth showed the effect of a large volume of air in preventing a rise in temperature. At a distance of 1,800 yds. from the shaft, with 80,000 cubic ft. of air passing per minute, the temperature was 55 deg., whilst at a distance of 2,600 yds. from the shaft, with 10,000 cubic ft. of air circulating per minute, the temperature was found to be 67 deg.

The normal temperature of the coal might be estimated, from the results of experiments at Seaham Colliery, to exist in a main air channel, which had been exposed to the air for some time, at a distance of about 13 ft. from the surface of the mineral. The highest temperature at which coal mines were worked was probably in Staffordshire and at the Monkwearmouth Colliery, where the temperatures varied from 80 deg. to 85 deg. At the Clifford Tin Mine, in Cornwall, the temperature was 120 deg., in which the miners could only work for 25 minutes consecutively, this high temperature being due to the heat of the water issuing from the rock. It would appear from the contradictory results of the experiments relating to the temperature of different minerals that no rule could be laid down. It was probable, however, that the temperatures of mines was affected to some extent by the varying conducting power of different minerals.

In regard to the increase of temperature with the distance from the surface, a careful comparison of all the experiments quoted and especially of those taken at a greater depth than 2,000 ft., led to the conclusion that, as far as could be judged from the experiments already made, the increase of temperature would be 1 deg. for every 55 ft. in depth, from the stratum of invariable temperature. The data afforded by the experiments were so irregular that no law could be established as to the ratio of increased temperature, augmenting or decreasing with increased distance from the surface, though the experiments at South Hetton and at Mouillelonge, as recorded in the paper, appeared to indicate that the rise in temperature became more rapid as the distance from the surface increased. Assuming the rate of increase in temperature to be as previously estimated, the normal temperature of a mine 7,000 ft. deep would be 176 deg.

Of the 3 modes by which heat was lost by one substance, and absorbed by another —radiation, conduction, and convection— the only influence likely to come into action in a well-ventilated mine of the

depth stated would be that of convection. From the observations recorded, it would seem that, as a rule, when the temperature of the surface exceeded 66 deg. the temperature at the bottom of the pit was less than at the top, but when less than 66 deg. at the top of the pit an increased temperature was found at the bottom. The increase in the temperature, due to the increased density of the air in deep mines, was estimated at 1 deg. for every 800 ft., making the mean temperature of the pit 7,000 ft. deep above 50 deg.

The effect of the heat emitted by workmen, candles, explosion of gunpowder, etc., was estimated not to have any appreciable influence on the temperature of the air circulating in the mine. The experiments at Seaham showed the temperature of the return air to be 0.5 deg. *lower* when the mine was in full operation than when the pit was off work, and when no lamps, workmen, etc., were in the workings. An unexplained cause of high temperature had been observed at several collieries, but more particularly at Monkwearmouth, where the temperature of the air on one occasion was found to be 95 deg., or upwards of 10 deg. higher than the normal temperature of the mineral. The question as to the effect of pressure upon deep workings was unquestionably of great importance, and necessarily very speculative. The mode of working coal, suggested for a depth of 7,000 ft., was arranged as far as possible in accordance with the principle that the coal should be removed so as to present long lines of fracture, and should be so worked as to cause the superincumbent weight of the strata overlying the goaf, or space where the coal was worked out, to have all its pressure upon such goaf, and a minimum pressure upon the coal. The increase in temperature in an underground air channel appeared to average about 1.5 deg. for every 500 yards.

The question of ventilating a mine 7,000 ft. deep to an extent sufficient to absorb the heat emitted by strata having a normal assumed temperature of 176 deg. was one of the most important in the inquiry, and the general results arrived at might thus be enumerated :—1. The temperature of the air was estimated to increase from 59 deg. at the bottom of the downcast pit to 65 deg. at the point where it reached the workings.—2. The length of time which would be occupied in cooling the main air-way to such an extent that the sides of the road would have an average temperature of 62 deg., and the normal temperature would be found as far as 12 ft. from the surface of the mineral, was calculated to be 40 days.—3. The total number of units of heat emitted by the strata per minute was found by calculation to be 45,320.—4. The volume of air introduced at the temperature of 65 deg., and assumed to leave the workings at a temperature of 89 deg., necessary to carry away this number of units of heat, was calculated to be 73,000 cubic ft. per minute.—5. Then, taking the total quantity of air necessary for the ventilation of the pit to be 110,000 cubic ft. per minute, the power required to produce this quantity would be 141 H. P., which represented an average temperature in the upcast pit of 90 deg., for the attainment of which mean temperature a temperature of 141 deg. was required at the bottom of the upcast pit.—6. The quantity of fuel necessary to raise the temperature of the return air from 96 deg. to 141 deg. was found to be 14.04 tons every 24 hours.

The laws upon which the amount of power necessary to produce a certain quantity of air under every condition was stated to be as follows : The pressure per unit of sectional area of an air-way required to overcome the friction of the air, varied directly as the length of the air channel, as the length of the perimeter, and as the square of the velocity of the air, and inversely as the sectional area of the air-way. The action of these laws was demonstrated in the several examples given, where it is shown that the power required to overcome the resistances varied as the cube of the velocity. In drawing a comparison between furnace and mechanical ventilation, it is calculated that at a depth of about 2,500 ft. the two modes of ventilating were equal, while below this depth the furnace became the more effective power.

In regard to the raising of coal, the probable limit from which it might be drawn at one lift was estimated to be about 900 yards, below which depth one winding-engine at the surface and one in the shaft would be required. An increase in the cost of sinking to great depths, and in the cost of producing the coal, must necessarily be expected ; but since the

selling price of coal would, to a great extent, be adjusted accordingly, this could scarcely be considered as a difficulty of much consequence.

The employment of machinery in place of manual labor would, probably, be found very beneficial in cutting and breaking down coal in deep mines having a high temperature. Some of the coal-cutting machines now at work were driven by compressed air, and the sudden decrease in temperature which compressed air underwent on exhaustion had been thought likely to be of use in reducing the temperature of a mine. In reality, however, scarcely any reduction could be anticipated, since the quantity of air exhausted bore so small a proportion to an ordinary current of air, that the effect on the temperature was only to be observed locally, and to a very slight degree. Of other modes which had been proposed for facilitating the working of coal at great depths, neither that of casing the air-ways with non-conducting substances, nor the employment of the electric light, nor the use of cold water and ice, could be anticipated to have any effect worthy of note. The hygrometrical experiments recorded showed that the dryness of the air was considerably increased with increased depth, especially in the return air-courses; and though this usually caused a high temperature to be borne more conveniently, it could not, in the case of the heavy labor required in working coal, be calculated to confer any benefit.

Finally, it might be stated that the question of working coal at greater depths than had hitherto been attained could not be considered to be one which presented difficulties of any importance, nor was it one which required immediate consideration.

The author had endeavored to prove that coal could be worked at a depth of 7,000 ft., but it would probably be centuries before such a sinking would actually be required, and improvements in the various descriptions of mining machinery, especially such as were intended to facilitate the getting of coal, would possibly before long render mining to such a depth as practicable as the workings of deep mines of the present day. Commercially, as had been observed, the question would adjust itself to the requirements and expenditure of the times.

PHYSICAL THEORY OF THE PRINCIPLE OF THE LEVER.*

By PROF. W. A. NORTON, of New Haven, Conn.

If it be true that two forces acting upon a lever will hold each other in equilibrio if their intensities be inversely proportional to their lever arms, it is plain that this principle must be a consequence of the law, or laws, of the lateral transmission of force from molecule to molecule of the lever, and therefore of one or more fundamental principles of molecular action consequent upon the disturbance of the natural equilibrium of the molecules. I propose to show that it may in fact be deduced from two admitted principles of molecular action. These are:

(1) If two integrant molecules of a solid body, which lie within the range of reciprocal action, be forcibly separated from each other a minute distance, a mutual attraction or repulsion will be brought into operation, and if they be urged nearer to each other by an equal minute distance an equal opposite force of repulsion or attraction will come into play.

(2) The intensities of the forces thus originating are proportional to the amount of the relative displacement of the two molecules, on the line connecting them.

To these fundamental principles are to be added that of the parallelogram of forces, as applicable to the case of two forces acting *directly* upon the same point.

The principle of the lever presents three distinct cases, which require separate consideration.

1. *The Straight Lever, with perpendicular forces.*
2. *The Straight Lever, with oblique forces.*
3. *The Bent Lever.*

Case I. *The Straight Lever, with perpendicular forces.* We will first take the lever of the first order, and consider the precise process of transmission of either of the extraneous forces acting upon it from the

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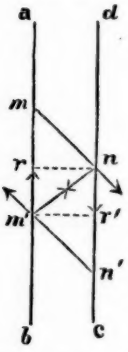
point of application to the fulcrum. Let *ab*, Fig. 1, represent a vertical line of

FIG. 1.



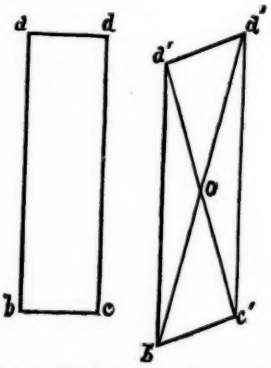
particles of one cross section, or lamina, and *cd* the contiguous vertical line of particles of the next section ; and let us conceive that all the similarly situated pairs of lines of the two cross sections or laminæ, are concentrated upon *ab* and *cd*, so that these lines may represent the entire cross sections.

Suppose that the extraneous force is directly applied to the first line, depressing it by a small amount. If we take one particle m' of the first line and consider the actions upon it of two particles n, n', of the second line at equal distances above and below it, it will be seen that m' will recede from n a minute distance, and approach n' by sensibly the same distance, and that the molecular forces brought into operation by these relative displacements will be opposite in their character, and equal in intensity. Thus, if the recess of m' from n develops a mutual attraction, the approach of m' to n' will develop an equal repulsion. The resultant of these two forces acting on m' will be directed upward, or from m' towards a. A similar result will be obtained for each pair of particles, n, and n', that exercise a sensible action on m'; except for those situated beyond a certain distance the forces developed, and consequently their resultants, will be reversed, or m' will be urged downward by the actions of such particles. Since m' is held in equilibrium in opposition to the extraneous force urging the section *ab* downward, the entire resultant of all the actions of the pairs of particles n, n', of the section *cd*, on m', will be directed upward. The section *ab* slips upon *cd*, under the action of the extraneous force until this resultant is equal to the extraneous force. By our second fundamental principle the amount of this slipping will be proportional to this force; since the actions of each pair of particles, n, n', will be proportional to this displacement.

Now if we take any particle n of the section *cd*, and consider the actions on it of two particles m, m', at equal distances above and below n, and at the same distances that n and n' are above and below m'; then, if the actions of n and n' on m' are such as to give a resultant directed upward, the actions of m and m' on n, will give a resultant directed downward, as shown by the arrows in the figure. These two resultants will be equal to each other. It follows, therefore, that the entire action of *ab* on n will be represented by a force acting downward equal to that by which m' is drawn upward by the action of *cd* upon it. This force will then be equal in intensity to the extraneous force. Accordingly the extraneous force will be transmitted from *ab* to *cd*; and in the same manner from this section to the next, and so on to the point of support. The transmission is effected by the slipping of each vertical section, or lamina, by the same amount upon the next, and so developing reciprocal vertical actions equal to the extraneous force.

Let us next seek to determine the longitudinal strains on the fibres, developed by

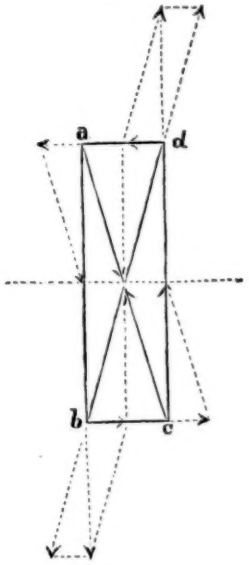
FIG. 2.



the extraneous force in the process of lateral transmission just considered. Let *ab* and *cd*, Fig. 2, represent two vertical

cross sections of the lever indefinitely near to each other, of which *ab* directly receives the force applied to one end of the lever. The relative slipping of contiguous laminæ causes the rectangle *abcd* to take the figure of an oblique parallelogram, $a'b'c'd'$; the diagonal *ac* being shortened, and the diagonal *bd* being lengthened. It therefore develops forces of compression taking effect from a' and c' toward the centre o of the parallelogram, and forces of extension taking effect from o toward b' and d'. The reactions to these forces take effect from o toward a' and c', and from b' and d' toward o. These reactions will urge the points a' and d' toward the left, and the points b' and c', toward the right; and the longitudinal strains on the fibres $a'd'$ and $b'c'$, thus originating at the angular points of the parallelogram, will be equal. For, supposing that there are only these extreme fibres, and that the diagonals $a'c'$ and $b'd'$ are material lines, the figure $a'b'c'd'$ is to be regarded as a system in equilibrium under the action of two equal forces along its vertical sides; that along $a'b'$ being the active force and directed downward, and that along $c'd'$ being the equal reaction of the fixed support transmitted to $c'd'$, and directed upward. One-half of each of these vertical forces will act at the upper and lower corners of the parallelogram. The reactions along the diagonals, above alluded to, will at these points sustain the equal vertical forces acting on them, and at the same time develop equal longitudinal strains on the fibres $a'd'$ and $b'c'$. Or, more directly we may regard the equal vertical forces, at the four angular points, as taking effect at the same time along the diagonals and along the fibres. This is illustrated in Fig. 3, in which the vertical forces soliciting the angular points of the parallelogram are represented by the halves of its vertical sides, or by equal lines. It will be seen that the longitudinal strains developed at these points will be represented by the halves of the horizontal sides; and therefore that the entire strains on the extreme fibres, due to the parallelogram considered, will be represented by these sides, *ad* and *bc*. If now we take the case as it actually is, and regard the entire area, *abcd*, as made up of fibres, the only result will be that the longitudinal strains, which upon the previous supposition would be developed along *ad* and *bc*, will be distributed over all the fibres lying between these extreme fibres and the middle one. What the law of the distribution may be it does not concern us now to inquire. It is plain that the individual strains will decrease from the outer fibres toward the middle one, where there will be no strain.

FIG. 3.



If now we take another vertical section indefinitely near to *cd*, it will form with *cd* another parallelogram, the vertical sides of which will be solicited, in opposite directions, by the same forces as those of the parallelogram just considered. The same strains as before will therefore be developed along the upper and lower fibres by these forces. The same will be true of each successive parallelogram into which the arm of the lever may be divided. The actual strain along any one continuous fibre, at the fulcrum, will therefore be equal to the strain on this fibre developed by any one of the parallelograms, multiplied by the number of parallelograms in the extent of the arm of the lever. Now if we suppose the two lever arms to be of unequal length, whatever may be the comparative intensities of the two forces that balance each other, each will give rise to a slipping of contiguous vertical sections, or laminæ, of its lever arm, proportional

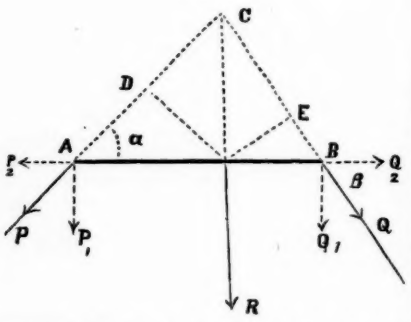
to those intensities, and so develop longitudinal strains on any fibre, in the extent of any single parallelogram considered, proportional to the same. Let p and q represent these proportional strains on a single fibre, and P and Q the forces applied to the lever, then $p : q :: P : Q$. Let m represent the arm of lever of P, and n that of Q. The number of equal parallelograms contained in these lever arms will be proportional to their lengths, m and n. The strain on the fibre considered, at the fulcrum, resulting from the action of P, will then be denoted by pm, and that resulting from the action of Q by qn. But the equilibrium requires that these directly opposite strains should be equal; and therefore $pm = qn$. Hence $p : q :: n : m$; and therefore $P : Q :: n : m$.

Since each of the forces P, Q, is transmitted to the fulcrum, by the slipping of each vertical section of the lever on the next, without change of intensity, the pressure there will be equal to the sum of P and Q.

The theory of the lever of the second order, as well as of the third, is essentially included in that of the lever of the first order; since the reaction of the fulcrum of the latter may be replaced by an active force, and either of the forces P, Q, by the reaction of a fulcrum.

Case II. *Straight Lever with oblique forces.* Let AB, Fig 4, represent the lever, and P, Q, forces obliquely inclined to it,—the

Fig. 4.

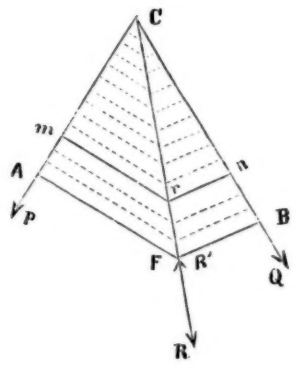


system being in equilibrium about some fixed point intermediate between A and B. Produce P and Q to their point of intersection C, and let CF be the direction of their resultant R, supposing them, for the moment, to act at C. Wherever the fulcrum may have to be, in order that P may balance Q, P and Q will be transmitted to it, by the process of molecular lateral transmission that has been explained, without change of direction or intensity, and therefore give a resultant pressure R', on it, having the same intensity and direction as R acting at C. Decompose P and Q as shown by the arrows, and suppose R' to be similarly decomposed into the components R_1 perpendicular to the lever, and R_2 lying in it. Then, since R' is the resultant of P and Q transmitted to the fulcrum, we have $Q_2 - P_2 = R_2$, and $P_1 + Q_1 = R_1$. Thus P_2 and Q_2 are neutralized by the component of the reaction of the fulcrum (which is equal and opposite to R') in the direction of the lever; since this component is equal and opposite to R_2. It follows, therefore, that the two components, P_1 and Q_1, perpendicular to the lever, will balance each other about the fulcrum. It now remains to be seen where the fulcrum must be situated, in order that P_1 may balance Q_1. From F, where the line of direction of R, through C, cuts AB, draw FD and FE, perpendicular, respectively, to P and Q, then by the parallelogram of forces, $P : Q :: FE : FD$;—and therefore P and Q may be represented by FE and FD. Now $P_1 = P \sin \alpha$, and $Q_1 = Q \sin \beta$; and $\sin \alpha = \frac{FD}{FA}$, and $\sin \beta = \frac{FE}{FB}$. Hence $P_1 = P \frac{FD}{FA}$, and $Q_1 = Q \frac{FE}{FB}$; or $P_1 = FE \frac{FD}{FA}$, and $Q_1 = FD \frac{FE}{FB}$. Therefore $P_1 : Q_1 :: FE \frac{FD}{FA} : FD \frac{FE}{FB} :: \frac{1}{FA} : \frac{1}{FB} :: FB : FA$. The fulcrum is therefore at the point F, where the line of direction of the resultant R, of the forces P and Q supposed to act at C, cuts the lever. But we have already seen that $P : Q :: FE : FD$. Hence these forces are inversely proportional to their technical lever arms, FE and FD. As P and Q are transmitted to the fulcrum without change of direction or intensity, the pressure on the fulcrum will be equal to R.

Case III. *The Bent Lever.* Let P and Q, Fig 5, be two forces acting on two points A and B of a body of indefinite extent, capable of turning about a fixed point F, situated in the plane of the lines of direction of P and Q. Produce these lines of direction to their point of intersection C;

and from F draw the perpendiculars $F A$ and $F B$. Divide $F C$ into an indefinitely great number of equal parts, and from the points of division draw parallels to $F A$ and $F B$. Let us first suppose that the point C falls within the body, and that this is of uniform thickness in a direction perpendicular to $A C B F$, and has the form $A C B F$. The perpendiculars to P and Q, from the points of division of $F C$, will divide the body, conceived to be represented by the area $A C B F$, into an indefinite number of similar portions of the bent lever form, with the points of intersection of the two arms on the line $C F$. Now let a represent the cross section of any one of these, on the line of P, and b the cross section of any one on the line of Q. P will be equally distributed

FIG. 5.



over the entire cross section $A C$, and Q in the same manner over $B C$. Let p and q denote the fractional portions of P and and Q that take effect at the ends of any one of the bent lever portions of $A C B F$. If we consider any one of these portions by itself, it will be solicited by the forces p and q, and be in equilibrium under the operation of these forces and some portion of the reaction R', to the pressure R, on the fulcrum, produced by P and Q. They will be transmitted inward by the slipping of contiguous sections, and neutralized by a certain portion of R′ transmitted along its line of direction; and the point in which this line intersects the bent lever portion under consideration must be its virtual fulcrum. Now if we consider the bent portion next to C, its fulcrum must be indefinitely near to C; while that of the first elementary bent lever, $A F B$, lies at F. But all the fulcra of the elementary levers must lie on the line of direction of R', which passes through F. Hence, as C is the fulcrum of one of these levers, this line of direction must also pass through C. Now the direction of R' is opposite to that of the resultant R, of P and Q supposed to act at C; since R' neutralizes P and Q transmitted, without change of direction or intensity, to F. Therefore, as its line of direction passes through C, it must coincide with the line of direction of the resultant R, of P and Q supposed to take effect at C. It follows, then, that the fulcrum F, lies on this resultant. But, by the principle of parallelogram of forces, we have, for any point, F on the resultant, the proportion $P : Q :: F B : F A$.

Now suppose a portion, $C m r n$, of the body $A C B F$, to be removed; the equilibrium will not be disturbed, since the only effect will be to augment the intensities of the fractional parts of P and Q that act on the elementary bent levers of the remaining portion, $m r n B F A$, without altering their ratio. Hence the forces, P, Q, which act on a bent lever and hold each other in equilibrio, are inversely proportional to their lever arms.

It will be seen from what has been stated, *in what manner the forces P and Q become neutralized by the action R′, or the reaction of the fulcrum.* Even when their point of intersection, C, falls within the body, they cannot be regarded as actually transmitted to C, and taking effect wholly there in opposition to R' transmitted and taking effect wholly at the same point. As a matter of fact it is only an infinitesimal portion of each force that operates at C. An equal indefinitely small portion p, q, or r, acts upon each elementary lever; and each triplet of forces taking effect on each elementary lever, counteract each other. In other words, the forces P and Q, instead of taking effect by direct transmission, wholly either at C or F, are actually distributed along the whole length of the portion of the line $F C$ that falls within the lever, and are there neutralized in equal elementary portions, by the corresponding elementary portions of R', transmitted to the same points.

If we suppose the body on which P and Q act, to have an indefinite extent, the only portion whose molecular forces will be called into play, in the transmission

and counteraction of the forces, will be that comprehended within the lines of direction of P and Q. This will comprise the part $A\ C\ B\ F$ already considered, and another part lying on the other side of $A\ F\ B$, that is on the side toward which P and Q solicit the points A and B. This part may be subdivided into elementary bent levers like the other, and its existence will have no other effect than to diminish the absolute values of p, q, and r, the triplet of forces answering to any one of the whole number of elementary levers, into which the entire portion of the body that lies within the lines of direction of P and Q is divided. It will be observed that for each elementary lever of this part, the resultant of the forces p and q will take effect upon the fixed point F, as a force of traction, instead of as a force of pressure, as in the case represented in Fig. 5.

We thus arrive at the general principle, that if two forces, whose lines of direction when produced intersect each other, are applied to a body capable of turning about a fixed point in the plane of these lines, these forces will be in equilibrio, provided *the statical moment of the one force is equal to that of the other.*

THE LAWS OF SEWAGE AND OTHER FERTILIZERS.

From "The Engineer."

Notwithstanding all that has been said on the subject, the utilization of sewage by irrigation is a process very much misunderstood, and there is danger least a prejudice should be raised sufficiently powerful to prevent the progress of a great sanitary and agricultural reform.

In the first instance, we will refer to some rather curious facts which may seem to tell against the principle we are defending, and which might be turned to great account by the opponents of sewage irrigation, though the facts, so far as we are aware, have not yet been prominently brought forward.

Every reader in his rural rambles will have noticed that pasture land is frequently dotted about with tufts of grass, growing in rich luxuriance, but which seem strangely neglected by the animals feeding in such fields. This ordinary phenomenon will be found to arise on pastures where there are cows only, or horses only. Where cows and horses feed together, these lumps of grass, which give the field an untidy appearance, are not perceptible. The explanation afforded is as follows:—Grass fertilized by cow-dung is repulsive to cows; grass fertilized by horse-dung is repulsive to horses; but contrariwise, grass fertilized by horse-dung is acceptable to cows, and grass fertilized by cow-dung is acceptable to horses. Hence, if both classes of animals feed together, the pasture is cleared, but not otherwise. The question arises, whether there is not here some law of nature which forbids that an animal should feed on vegetable matter built up from the excreta of the species to which the animal belongs. Chemistry would say that the elementary bodies which enter into the constitution of a plant are the same, let the source of such atoms be what it may; yet, on the other hand, it is well known that the flesh of an animal is affected by the character of its food. There is "one flesh of men, another flesh of beasts, another of fishes, and another of birds." Yet, "while all flesh is not the same flesh," who has not tasted fishy pork and fishy birds? May not, then, the tissues of a vegetable be affected by the nature of the food upon which it has fed? May not the essential atoms and the specific structure be associated with compounds varying according to the character of the source whence those essential atoms were derived? A given volume of water in the Thames may have obtained part of its bulk from the liquid sewage of a town; the sewage itself may have been thoroughly oxygenized, so as to have entirely disappeared; yet certain nitrates and nitrites existing in the water of the river, will show that its previous history differs from the antecedents of a stream among the Welsh mountains. The nitrates may or may not be injurious, but, in any case, their presence is a peculiarity. May not some peculiarity attach to plants according to the nature of the manure on which they were reared? It may be said that the cow or the horse is simply repelled by the

smell of its own dung, and has no real distaste for the grass. The answer is, that the aversion continues until some considerable time after the disappearance of the dung, although the dislike becomes less marked as time goes on. Certainly there is this peculiarity from the very commencement, that each animal will feed on grass fertilized by the dung of the other, while refusing that which its own dung has fertilized. Carrying this law, if it be such, into a higher grade, are we to say that man should reject the wheat reared by the sewage of towns? Should he also reject the flesh of animals reared on sewage farms? With regard to the meat question, we may observe that the horse eats the grass fertilized by the cow, although the cow itself eats grass fertilized by the horse. By parity of reasoning, we may argue it is safe for man to eat the flesh of a bullock which has been fed on Italian rye grass, even though that grass were fertilized by town sewage. If we are rightly informed, cows and other animals are very unwilling to graze where sewage manure is fresh on the land. This aversion exists until the manure has well sunk in the ground, after which all quadrupeds will feed readily on the produce. When cows are fed on Italian rye grass, the grass is generally, if not always, cut in the field, and conveyed to the cows, the animals being kept in sheds. Thus the animals are fed with the cleanest portion of the grass, presuming the land to be irrigated with sewage distributed by open carriers, and not by means of the hose and jet. So far the animal is tolerably sure to be fed on vegetable matter which has thoroughly assimilated the sewage elements. This may, in some measure, answer the objections of Dr. Letheby and Dr. Cobbold, who argue that if sewage is applied to land where animals are fed on green crops, a very serious effect will be produced upon the animals so fed, and upon human beings who eat the flesh of such animals. Nature seems to have given a discriminating appetite to the cow, and, we may presume, to other animals also, so as to guard against the peril which otherwise might prevail. Our information is less complete with regard to the sheep than in the case of the cow; but, we may ask, whence arises that minute "lumpiness" of the turf on the downs where sheep alone are fed? May it not be that these animals have an aversion similar to that of the cow and the horse; and being equally dainty with them in this respect, may be equally cautious in reference to sewage?

But if safe with regard to flesh, is man equally secure in feeding direct on a sewage-grown vegetable? Perhaps this question is partly answered by the fact that where town sewage is not employed, something equally filthy is often used as a fertilizer. The extensive and inevitable use of manure proves that very disagreeable ingredients may help to produce agreeable and wholesome food. If we may not use any manure at all, the fertility of our fields must cease. If we may use one kind of manure, why not another? If the plant can thrive on the manure, why may not the animal thrive on the plant? The disgust of the cow and the horse for the produce of its own manure has its limits, and those limits seem to show that when manure is thoroughly assimilated offence ceases. A soil sodden with sewage, or in any way overstocked with the elements of sewage, may possibly be unfit for the growth of wheat. But, on the other hand, excess of manure, of whatever sort, might be held as dangerous. The true principle appears to be this: That sewage should be applied in moderation, so as not to declare its presence. It has been the common fault first to take a quantity of sewage, and in the next place to try and "get rid of it." Under such a mode of treatment the land deluged with sewage has become a positive nuisance. Many respectable authorities have a notion that town sewage is so highly diluted that a large quantity must necessarily be used; but the result belies the argument; for the land refuses to take so large a dose. The excess of sewage lies upon the ground and pollutes the air. A nuisance is created, and it is a law of nature that where sewage is wasted a nuisance shall be experienced. The utilization of sewage really means that the sewage shall be "used." When sewage is "used" its power of offence ceases. Dr. Letheby refers to Croydon as an example of sewage irrigation; but it is a bad example. Dr. Letheby states that the subsoil water at Croydon is so mingled with sewage that the wells are thereby polluted. This is just so much waste. The sewage ought to be in the plants and not in the wells.

Referring again to the phenomena of the pastures, we would observe that each tuft of grass is an instance of waste. Who would think of covering a field all over with cow-dung 2 or 3 in. deep so as to hide every particle of earth? And why should there be such a depth anywhere? If the cow-dung were mingled with water until it had the strength of ordinary town sewage, and were then distributed over an area sufficient to absorb it, so that in 20 min. no smell should be perceptible. and if liquid manure of this description were applied only once in the course of several days, would there be any difficulty in feeding cows on land thus treated? Would not the grass in such a case resemble that which grows when the ordinary cow-dung has not only disappeared but has really entered into the constitution of the plant? All the phenomena we have mentioned seem to enforce one lesson, namely, that every inch of ground demands the restoration of that which it first gave up, and that to spread on one inch the manure belonging to two is a waste and a misapplication which natural laws resent. Further, we may allow that the rule is particularly strict in those cases where the animal is its own fertilizer. As a corollary it may be asserted that the use of town sewage does not preclude the employment of other manures, natural or artificial. There is particular reason to believe that, in the case of wheat, other manures beside town sewage are needful in order to bring the plant to perfection.

COMPOSITION OF WOOTZ STEEL.

From "The Engineering and Mining Journal."

In the "Industrie Zeitung," we find an analysis of this East Indian steel, by Prof. Rammelsberg, of Berlin.

The Wootz or Bombay steel has been celebrated, from olden times, for its surpassing hardness, which has given it the first place for the manufacture of cutting instruments. According to several authorities, it is made by smelting a pure, sandy magnetic ore in small furnaces, by which means blooms weighing about 40 lbs. are made. These are hammered out, cut into pieces and melted with chips of the *Cassia Auriculata*, an East Indian plant, in a clay crucible with an air-tight cover. Twenty to 24 of the crucibles, each containing only a pound of material, are heated at once in a small blast-furnace, and in each crucible is found at the end of the operation a small smelted lump of cast-steel. It is said that only 12 per cent. of the iron contained in the ore is saved in this way. Wootz steel is therefore a cast-steel, which partially accounts for its good quality.

In 1819, Faraday, in connection with Stodart, undertook an analysis of Wootz steel, which attracted considerable attention from the fact that they found alumina as well as carbon and silicic acid. From this fact they concluded that silicon and aluminium imparted to the East India steel its peculiar properties. They found 0.03 per cent. of silica and 0.7 per cent. of alumina, not in the solution of the steel in aqua regia, but in the black, carbonaceous residue, when subsequently heated to redness in a silver crucible with caustic alkalies. This manner of procedure, in the light of the present advancement of chemical science, is sufficient to place the accuracy of the result in doubt. Karsten, who accomplished so much in iron investigations, found only doubtful traces of aluminium. T. H. Henry afterwards analyzed a sample the genuineness of which was doubted, and found

Graphite	0.312	per cent.
Combined Carbon	1.336	"
Silicon	0.044	"
Sulphur	0.175	"
Arsenic	0.036	"

but no aluminium.

The collection of the Royal *Gewerbe Akademie* in Berlin contains a sample of Wootz steel, the genuineness of which is guaranteed by a certificate of the East India Company. A portion of this bar was broken off and used by Rammelsberg for his investigations, of which he gave the following account to the Chemical Society of Berlin. The specific gravity is 7.822, instead of 7.728, as given by Henry. It dissolves in hydrochloric acid, leaving only a very small white residue. It contains, therefore no graphite. The solution in

hydrochloric acid gave no trace of copper or arsenic when treated with sulphuretted hydrogen. For the determination of carbon, it was treated with water with the addition of bromine; the carbonaceous residue, when burned in oxygen, left likewise no trace of graphite.

Sulphur was determined by passing the gas generated by the solution in hydrochloric acid through a solution of chloride of silver in ammonia. The dark precipitate was oxidized by means of nitric acid, and after precipitating the silver, the sulphuric acid was precipitated as sulphate of baryta. The nitric acid solution was evaporated to dryness in a platinum vessel, the residue heated alternately in hydrochloric and hydrogen gas, and left after driving off the sesqui-chloride of iron, a residue of silicic acid, which disappeared by heating with fluoric acid. The Wootz contained no trace of aluminum.

The result of the analyses was

Carbon	0.867 per cent.
Silicon	0.136 "
Phosphorus	0.009 "
Sulphur	0.002 "

Henry found altogether twice as much carbon, one-third of which was in the form of graphite. But inasmuch as he had softened the steel, in order to be able to get filings to burn with oxide of copper, it is possible that the softening may have given occasion for the formation of graphite, although Karsten is of the opinion that soft steel contains no graphite. Rammelsberg found three times as much silicon as Henry, and one of Abel's analyses shows that a great deal more may be contained in cast-steel. Henry, furthermore, reports no phosphorus as present, but on the other hand gives arsenic, which is certainly not present at all. Finally, it is to be noted, that Henry gives such an amount of sulphur that the steel would be valueless; for, according to Karsten, wrought-iron containing 0.034 per cent. of sulphur is in the highest degree red-short, and 0.01 per cent. is the boundary for the use of iron.

A great many analyses of iron give, like Henry's, altogether too high a percentage of sulphur, in consequence of the method pursued in its determination. Is there, after all, any such thing as an aluminum steel? Faraday heated steel with coal dust, and the resulting dark grey, foliated product (cast-iron) he heated to a high temperature with pure alumina. He produced a white, fine-grained, very brittle mass, which contained, according to his analysis, 3.4 per cent. of aluminum. When from 6 to 12 per cent. of this was smelted with good steel, the product was a steel possessing the excellent characteristics of the Wootz. The reduction of the alumina, under the circumstances, was very remarkable, and the experiment should be repeated, with the direct use of aluminum, which Faraday could not obtain. The experiment of producing aluminum steel has often been tried but the samples that Rammelsberg has received as such, have always failed to show the presence of aluminum.

Among the many important engineering undertakings in the railway annals of Scotland, the deviation line for the purpose of abolishing the level crossing at Coatbridge may be considered as one of great importance. The chief feature of the new line will be the iron bridge which is to span the present level crossing. It will be built on the same principle as those bridges connecting the streets through which the Union Railway passes in the city of Glasgow, and will consist of massive ashlar abutments 20 ft. in height, with a span of 120 ft., whilst strong malleable iron girders will support the structure. The bridge when finished will cost £6,000. This new line, which will be opened for traffic in a few days, was subjected to a preliminary inspection on Saturday afternoon by a number of the directors and officials of the company, along with Mr. Waddell, the contractor. An engine with 2 carriages left the siding beyond Sunnyside station about 3 o'clock, and passed along the entire length of the line. The inspection was believed to be very satisfactory. The North British Company deserve credit for expending a very large sum of money in order to abolish the very dangerous level crossing at Coatbridge.

Large quantities of bowl sleepers are being made at the Hartlepools, England, for shipment to India; they are intended, of course, for use on Indian railways.

THE THAMES STEAMBOATS.

From "The Engineer."

London is a city of contrasts. The great centre of wealth and of all the refinements and luxuries that follow in its train, it has yet its city Arabs whose squalor and wretchedness would disgrace a Hottentot village, and its eastern districts, whose monotonous and unbroken poverty makes the heart of every honest passer by ache. The source of every great enterprise destined to change the face of either the old world or the new, it is yet the home of the most insensate conservatism, clinging to old habits, old ideas, old systems condemned by all the common sense of a hundred years ago. Rushing with eager haste, north or south, after the objects of its earnest pursuit, its multitudes still put up with street blocks, through restive gas companies, or incompetent vestries, or broken-winded cab horses, or through the freaks of omnibus companies, or a thousand other hindrances just as curable as hunger at a well-spread board. Let a citizen with taste and wealth build himself a commercial palace that adorns his street, ten to one but his neighbor refuses, on any terms, to remove the ugly, dingy pile next door which has been an eyesore for generations. The metropolis maims or slaughters her citizens daily in the streets, but then she provides the most comfortable of almshouses and the most wonderful of hospitals. She has the most gorgeous of lord mayors, the most renowned of aldermen, the most active of vestries, the most potent Board of Works, lords many, and officers more; but if your dustman is restive, who shall say how he is to be reduced to reason; or if the Brighton Railway carries you through the most pestiferous of stenches day by day, and year by year, whence shall come the remedy? Most advanced of Liberals are we of the City, and have bearded sovereigns and baited Papists from the days of old; but as for adapting our city government to the wants of to-day, we should as soon think of it as of giving up the Lord Mayor's old state coach. We have "purified" the Thames, but it is at the cost of polluting Barking. We have built a noble river wall, but then we hand a good portion of the gain to the Duke of Buccleuch and the Metropolitan District Railway. We have spent some three millions on a noble palace for our River Bank, but it is all going to decay because we would not have a man at two pounds a week to see that decent stone was used in its construction. We employed the best talent the country could furnish to design and build our palace, and now we hand it over to "the noble savage" to do with it as seemeth good in his eyes. We have recently erected the handsomest of bridges across our river, but then we had taken care to have the ugliest of structures to run by its side. Our noble Thames is the trading highway of all nations whom we tempt by the chances of gain; but are there anywhere such scoundrels ashore who waylay the helpless visitant, cheating him, plundering him, and all practically unchecked by law or police? Could even the most worldly-wise native undertake to visit a vessel lying midstream without being plundered by the boatmen? But what do our rulers? It seems scarcely reasonable to expect they should protect native or foreigner.

Of all the mean, shabby, disreputable things, embodying the discomforts, the helplessness, and the ugliness of a bygone day, commend us to our river steamers. We have banished our old ramshackle piers—at least the most outrageous of them—thanks to the Embankment, but alack for the boats that come alongside the new structures. It is not fate, but the Citizen Company, that condemns us to sit on a blazing deck, or to descend into a stifling hold, knocking one's head withal at its depressed entrance, and against its low ceiling at every step, unless rejoicing in a stature of five feet nothing, or blessed with a flexibility of the spinal structure beyond the wont of most men. Why the Thames boats should not have the comfort of an awning on deck in hot weather is inscrutable to us, or why the cabins of these boats should not be easy of access, and comfortable when reached, we really cannot tell, except that such reasonable attentions to the wants of passengers are not after the ways of Englishmen, till they are compelled. There seems to be a residuum of insular surliness even in the members of a metro-

politan company, which says: "We carry you people to be sure, and we will make our dividends out of you ; but as for studying your comfort, or dealing with you in a suave and pleasant way, not a bit of it ; we will just be civil enough to decoy you into our dens, and then our spleen and bile shall scatter spray over you, and expose you to the glare of the sun, and cramp you in low cabins, and disgust you with the presence of all ugliness, and the absence of all elegance, because we delight in it, and the masses were designed by Heaven for the sport as well as the support of the few."

A Thames steamboat is easily capable of every desiderated appliance. She might be roomy, lofty, airy, sheltered, abounding with convenience and comfort ; she might even be elegant, built with good proportions, correctly planned, adapted to all the needs of her traffic ; she might even further be beautiful with art in her fittings, and art in her decorations, and art in her appliances. And well would it repay some one to inaugurate this new era. The old manner is said not to have paid very well—pity if it had. The new would, nevertheless.

It is hopeful to see just the scintillation of a sign that even the Citizen Steamboat Company will be compelled to "move on." Formerly to get from the Temple Pier to London Bridge one had to take one boat to St. Paul's Pier and another to the Surrey side. The Metropolitan Railway has already cured that. The same boat now goes the whole journey. We accept the sign as the opening of a new epoch. The spirit of competition is working over the "silent highway," from time immemorial the manor of monopoly. Let the Metropolitan Railway get to London Bridge, and compete along its whole line with those old weird creatures of "Citizen boats," and sundry other signs of healthy competition will soon appear. Taste, progress, even self-interest were powerless to effect the work that buds at the first touch of competition. We are not without warm hopes before very long to have the pleasing duty of presenting to our readers drawings and descriptions, not of a new and luxurious yacht for the Khedive, or even of a more elegant though less luxurious steam yacht for her Majesty, but of a handsome and commodious Thames penny steamboat.

The quantities of railway iron exported from the various ports of the United Kingdom during the month of May last reached, the "Times" states, the large total of 131,208 tons, as compared with 87,392 tons in May, 1869. Out of this Russia took no less than 82,741 tons, against 23,120 tons in May, 1869, and 10,011 tons in May, 1868. The United States also took 33,175 tons, as against 25,557 tons in May, 1869, and 24,221 tons in May, 1868. In the five months ending May 31 this year, the reports reached an aggregate of 437,235 tons, as against 320,745 tons in the corresponding period of 1869, and 233,769 tons in the corresponding period of 1868. A large increase is thus shown in the exports to Russia, while an appreciable increase is also shown in the quantities sent to the United States. The exports have also increased to Prussia, Holland, Spain, the Danubian Principalities, Cuba, Brazil, Chili, British India, etc. ; but they have decreased to Sweden, France, Egypt, Peru, British America, and Australia. The value of the railway iron exported in May was £1,050,154 against £697,022 in May, 1869, and £433,246 in May, 1868 ; and for the five months ending May 31 this year £3,521,561, against £2,480,594 in the corresponding period of 1869, and £1,809,030 in the corresponding period of 1868.

An exchange paper gives the following as the latest measurement of the North American lakes : The greatest length of Lake Superior is 335 miles ; its greatest breadth is 160 miles ; mean depth, 688 ft. ; elevation, 627 ft. ; area, 82,000 square miles. The greatest length of Lake Michigan is 390 miles ; its greatest breadth, 108 miles ; mean depth, 900 ft. ; elevation, 506 ft. ; area, 23,000 sq. miles. The greatest length of Lake Huron is 200 miles ; its greatest breadth is 160 miles ; mean depth, 600 ft. ; elevation, 274 ft.; area, 20,000 sq. miles. The greatest length of Lake Erie is 250 miles; its greatest breadth is 80 miles ; mean depth, 84 ft. ; elevation, 555 ft. ; area, 6,000 sq. miles. The greatest length of Lake Ontario is 180 miles ; its greatest breadth is 65 miles ; mean depth, 500 ft.; elevation, 260 ft.; area, 6,000 sq. miles. The length of all 5 is 1,584 miles, covering an area of upwards of 90,000 miles.

LATE EXPERIMENTS ON HEATON STEEL.

Translation from "Der Berggeist," through "Zeitshrift für Berg und Hütten Wesen."

In his account of the Heaton process, published in 1869, Gruner stated that 0.002 @ 0.003 of phosphorus does not hinder the working of hot steel, and that it increases the resistance of cold steel to tensile force. But its brittleness is increased, so that it is more sensitive to blows and shocks ; the presence of phosphorus being attended by a corresponding want of temper or fibre.

Fairbairn has since obtained more favorable results at Manchester ; but these are found upon critical examination not to disprove, but rather to confirm the statements of Gruner.

At the 39th session of the British Association for the Advancement of Science, Fairbairn presented the results of his numerous experiments, giving at the same time a sketch of the Heaton process, illustrated by a drawing of the apparatus.

He had subjected 6 bars of steel of the Langley mill manufacture to the tests of bending, tension, and compression, and obtained results which seemed to show the superiority of Heaton steel over Sheffield steel.

We give an abstract of the results of these experiments:

Heaton steel shows a superiority to other kinds in resistance to deflection in a ratio of 1.3 : 1.

The active elastic resistance is $1\frac{3}{4}$ times as great as the average of other steels ; so that it is specially fitted to resist impact and extraordinary pressure.

The flexibility and the coefficient of elasticity of this steel are small, being a little below the average value. The mean breaking-load of the 6 bars is larger than the general average ; and as the bars lengthen considerably, we infer a greater active resistance to fracture. The resistance to compression is the same as with ordinary steel.

Fairbairn predicts an important future for Heaton steel ; particularly as it can be made from pig-iron of inferior sort.

As these experiments with Heaton steel did not agree with results which Gruner had derived from the experiments of Kirkaldy (with steel from the iron of Longwy and Hayange), he resolved to find the proportion of phosphorus in the rods employed by Fairbairn. The pig-iron, bright gray and a little graphitic, from which the steel was made contained—

Silicon	0.0210
Phosphorus	0.0106
Sulphur	0.0019

and was refined in Heaton's converter with 12.4 per cent. Chili saltpetre and 1.2 per cent. quartz sand.

According to Gruner's earlier experiments the quantity of saltpetre applied seemed to be insufficient ; and it was supposed that the product of refining still contained foreign substances.

The analysis of the six bars gave—

	1.	2.	3.	4.	5.	6.
Carbon	0.0049	0.0057	0.0052	0.0054	0.0054	0.0047
Silicon	0.0010	0.0012	0.0016	0.0010	0.0012	0.0009
Phosphorus	0.0030	0.0023	0.0024	0.0024	0.0028	0.0023
Sulphur	No trace	0.0001	0.0001	0.0001	Very slight trace.	No trace.

It is seen that the bars have nearly the same proportions of these elements, as might be inferred from their common origin. They are not very hard ; are easily filed, containing 0.005 @ 0.006 of carbon, but at the same time 0.0023 @ 0.0030 of phosphorus.

It would then seem to follow, if Fairbairn's results were correct, that 0.002 @ 0.003 per cent. of phosphorus improves steel, especially by increasing elasticity and resistance. This might hold for these functions of cohesive strength, and yet it would not follow that the same steel bars could also resist the vibratory effects of impact. It may be easily inferred from Fairbairn's results that these tests show the same defects in the steel as were found

in the experiments of Kirkaldy. The bars gave evidence of brittleness and want of temper, and seemed not in condition to resist the molecular disturbances of shocks and blows.

Again it must be remarked that the maximum of elastic extension, which is calculated from experiments in deflection, must necessarily be less than the tearing weight which is applied in direct experiments in tension. But it must be remembered that a rod often parts before the whole load is hung upon it; the effect of a slight disturbance or a shock. The cause lies in the nature of steel, depending on a certain brittleness and shortness of grain.

In the earlier experiments of Fairbairn with English steels (1867), such a condition was shown with very hard steel:

A steel No.	1,	broke at	37.96	tons,	its elastic limit being	30.53	tons.
" " "	37,	"	39.75	"	" "	39.08	"
" " "	39,	"	38.02	"	" "	35.02	"

The same tests gave for—

No.	1,	contraction,	0.00	; elastic extension,	0.006	; permanent extension,	0.0025	tons.
"	37,	"	0.02	; " "	0.0106	; " "	0.0106	"
"	39,	"	0.01	; " "	0.002	; " "	0.0012	"

On the other hand soft steel often gives

Contraction	0.50
Elastic extension	0.10 @ 0.15
Permanent extension	0.15 @ 0.20

The experiments with 6 bars of Heaton steel gave the following results. Two bars parted before the load reached the maximum corresponding to the limit of elasticity:

No.	2 at 41.70	instead of	47.27 tons.
"	4 " 46.82	"	48.56 "

Brittleness was shown in the fact that 4 bars parted without contraction, very suddenly, though the suffered an extension of 0.031 to 0.094. Hence brittleness depends not upon the degree of hardness, but upon a lack of flexibility or fibre.

Softness of steel is shown not only by small percentage of carbon and ease of filing, but also by the extension caused by lateral compression. This amounts to 0.247 @ 0.333 to the square inch for 100 tons, while the hard kinds of steel show a compression of not more than 0.15 @ 0.24.

Hence steel containing phosphorus is brittle without being hard.

Another property of this product is its stiffness and great elasticity. Referring all depressions to the limits of elasticity and the transverse resistance of 1 English square inch, the 6 bars of Heaton steel give values which lie between 1.01 and 1.88 inch. The mean of the other bars is 1.30 @ 1.50 in., and in 3 cases out of 45 the depression exceeds 1.60 in.

It is therefore to be inferred that increased service can be had only for permanent loads, not for those which are sudden and variable.

Gruner sums up in the three following statements:

(1.) Phosphorus in the proportion of 0.002 @ 0.003 makes steel stiff and elastic, increases its elastic tensile resistance and its breaking resistance, without altering its hardness. But this steel, even if but little carbonized, lacks in temper and is short-fibred and brittle.

(2.) To discover the injurious properties it is necessary to apply, not only tensile and transverse loads, but also impact and blows.

(3.) Fairbairn's experiments do not warrant us in condemning the Heaton process finally; for, as was the case in the experiments with Lothring iron, the proportion of saltpetre to silicon was too small.

In conclusion we give the Heaton process as prescribed by Gruner:

(1.) Removing the phosphoric earths from pig-iron by blast and putting into the refining fire.

(2.) Refining the pig-iron and greatest possible diminution of the silicon.

(3.) Drawing from the refining fire directly into the Heaton converter upon a sufficient quantity of saltpetre.

(4.) Working of the blooms in a Siemens-Martin furnace.

Now that the high-level bridge scheme is abandoned, it is expected that a strong effort will be made in the coming session of the British Parliament to obtain the necessary powers for a tunnel under the Severn at New Passage.

STEAM ON COMMON ROADS.

From "The Engineer."

What is the true reason that we nowhere see the steam-engine used to any great extent for common road traffic? There is probably no problem in the whole range of practical mechanics, and there is certainly no other problem in steam engineering which has taxed ingenuity so long, so much, and yet with such comparatively slight results. Almost innumerable inventors, dating from Cugnot, have been trying their hands at it for more than a century. It is true that their work has not been without some fruition. Steam traction engines now carry themselves and their ploughing tackle in farm operations; they are used for drawing heavy loads for short distances on special bits of road; but that is nearly all. Road engines have never yet found general application in England; and, after many different trials at various times, they have almost completely failed in France, in Germany, and America. The multiplicity of the proposals and attempts in this direction is remarkable. We have Savery, and later, Dr. Robinson, ten years before Cugnot's trial, proposing the thing. Then Oliver Evans; in 1784 Watt patented the application of his engine to the purpose; William Symington tried it; and afterwards Murdoch. Oliver Evans actually propelled an engine of some size. The most ingenious attempts were mady by Trevithick; and, after him by Gurney, Gordon, Ogle, Dr. Church, and Dietz in France. The curious, and perhaps significant, point about the history of these attempts is that the principal ones were renewed with an interval of a generation between each. Thus, after the first schemes in 1759–69, we find Trevithick working in 1802–4: Gordon, Church, and many more in 1832–6; and, lastly, Boydell, Aveling, and others, from 1855--65. We have now another ingenious plan, but in spite of all that we have lately heard from Edinburgh about Mr. Thompson's road steamers, we are not inclined—while we wish him every success—yet to make an exception in his favor. In the first place, they have not worked long enough; and, in the second, we do not know the proportion that the excellent roads in and about Edinburgh have contributed to his success. In fact, isolated cases of the partial success of steam power on common roads can generally be traced to the good state of the roads in the given locality.

Trevithick, the greatest genius amongst traction engine inventors, seems at first to have even believed that "railroads are useful for speed and for the sake of safety, but not otherwise; every purpose would be answered by steam on common roads which can be applied to every purpose a horse can effect." In this there is, of course, an evident fallacy. The only reason that greater speed is obtainable on a pair of rails, with a locomotive and its train, than if the locomotive and train were put on a road without rails, is that the rail offers a hard, smooth, unyielding surface, and that the ordinary road offers a soft, rough, and yielding surface. If we took an ordinary train of a locomotive and carriages, turned the flanges off the tires, and placed them on an iron road, made with one smooth level surface—one long metallic table, in fact—we could evidently get the same speed on such a road—which we may suppose perfectly straight and sufficiently wide to get over the difficulty of our want of flanges—as on a nordinary line of railway. As soon, therefore, as a locomotive and train were got to run on rails, it might have been seen clearly that the locomotive steam-engine did not want improving, but that, in order to put steam power on roads, it was the roads that wanted improving. In fact, only a year or so after his patent for 1802, Trevithick came to the conclusion that steam carriages could not be placed on common roads before common roads were radically improved and rendered able to bear heavy loads without giving way and increasing the draught to an impracticable amount. Some of the more able later inventors of traction engines saw this, more or less clearly, and attempted to make the engine carry its own railway, though we are not aware that even Boydell's traction engine and endless railway are now anywhere in practical use. After making the most successful road traction engine of any, we now see Messrs. Aveling and Porter taking the

lead in the production of steam road rollers.

Briefly, the whole future of the application of steam to common roads clearly lies in the improvement, not of the engine, but of the road. In the same way as rails must be laid down before running the locomotive, so must common roads be rendered able to bear heavy weights, and have given them a hard level surface, one approaching as nearly as possible that of the rail table. The nearer this condition of hardness is approached, the more extended will be the use of steam on common roads.

These premises being granted, the solution of the old problem of applying steam to common roads is simply to be found in the general use of the steam road roller. The steam roller must precede the steam traction engine. Experience shows that this process of road-making and maintenance gives us a hard level surface, not liable to sink and take ruts under the wheels, and affording more than sufficient adhesion for propulsion with smooth wheels. The possibility of applying steam in this way would give us what might be termed a universal tram-road, rendering available for steam power our 200,000 miles of macadamized roads. Much in this sense was a passage in a late public speech of such an experienced engineer as Sir Joseph Whitworth, in which he pointed to the improvement of common roads, rather than an extension of tramways. The roads are there, and their improvement by the process, instead of involving an outlay of capital, actually greatly reduces the cost of their maintenance. In our especial case the employment of an engine on common roads, able to move about with facility, also means the application of steam to the conveyance of stone from the various deposits along the road; to breaking it up and taking it to the required spots before rolling it down. Of extraordinary value would these applications of steam be in countries with such dear labor as that of America.

FLEXIBLE TUBE ENGINE.

From "The Revue Industrielle."

This remarkable machine, working either by aid of a vacuum or of compressed air, was designed and constructed by M. Eugene Bourdon, a skilful French mechanician.

The originality of the principle, and the perfection of the execution of this new machine, appear to us to merit the attention of engineers, and we are glad to be able to present to our readers the above design, which we owe to the kindness of the inventor. The "Revue Industrielle" having specially for its aim the setting forth of new mechanical combinations and industrial progress of all kinds, we shall have occasion often to speak of the productions of M. Bourdon, for he is one of the few engineers who have created machines, and who have known how to employ the more important physical properties of matter.

The cylinder, as may be seen, has been replaced by a flexible tube of brass or steel having an elliptical section.

The piston has been omitted, as also have been connecting rods, stuffing boxes, and slides.

The principal organ exhibits a strong likeness to the manometer tubes of the same inventors; and it is for the reason that this latter instrument has served its purpose so well for so many years that this new application of the same feature affords good promise of success.

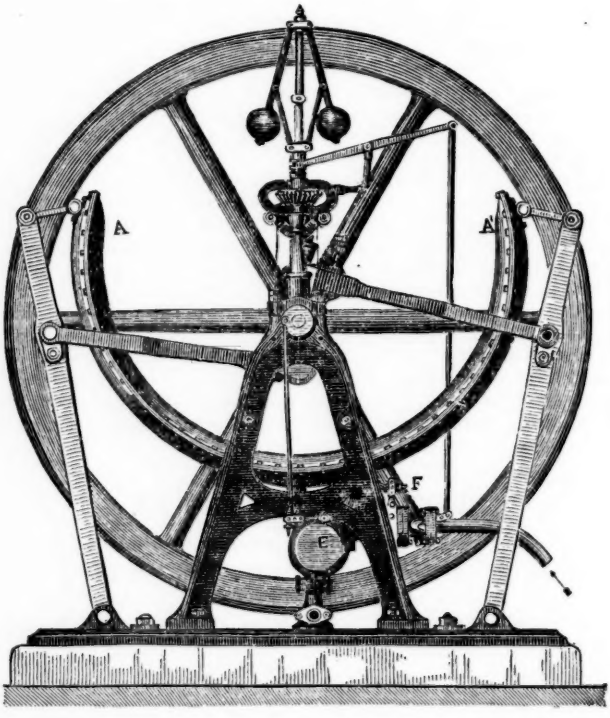
The extremities of the crescent A A′ are alternately forced towards or away from each other by the introduction of compressed air into the tube. This back and forward movement is transmitted to the central shaft by means of the levers and cranks as shown in the figure. There is a slide valve at E, and a throttle valve at F, worked by a governor.

In some cases the governor is omitted, for the purpose solely of simplifying the construction; M. Bourdon considers it inexpedient to omit it in the general use of the engine, as the vibrations would become too rapid and the tube would deteriorate.

In order to compress or rarefy the air the inventor employs the water from the public service pipes; this supersedes the necessity of use of combustibles. This is

a favorable circumstance when simplicity of working and healthfulness are regarded, but quite unfavorable from an economical point of view.

We want several elements to be able to establish a theory for the flexible tube machine. The inventor claims that its useful effect ought to be considerable as



a consequence of the elimination of the friction of the piston and connecting rod. It seems to us that it may be claimed that this new machine is too complex. Be that as it may, it works well, and that is the important fact which we wish to record now.

The chief advantage of the absence of a piston is not a diminution of friction, but the avoidance of possibility of leakage, and we believe that in the use of steam this arrangement would be preferable to most rotary engines. So, for example, in a shop where there were twenty machines and a single boiler, by using oil as a combustible the expense of consumption for each machine would be very small, considering the low price of the fuel, whatever may be the reduction of useful effect of the tube.

We shall recur to this interesting subject when we have the results of experiments to communicate to our readers.

M. E. Becquerel says: "The electrical effects produced by the contact of non-oxidizable metals and distilled water (chemically pure) are due, not to any special action of contact, but to the reaction of the water upon the gases condensed on the surface of these metals. The effects vary according to the molecular state of the metals and their temperature. As regards, however, the oxidizable metals, the electrical effects produced by heating them are due to the very slight layer of oxide adhering to their surface, whereby they are rendered positive toward the unpreserved metallic surface."

ELECTRO-HEATING.

By W. LEIGH BURTON, Richmond, Va.

It is well known that much time and money have been spent in experimenting with electricity with the view of utilizing it for various purposes, but it is probable that the idea of obtaining from it a motor has received the largest share of attention. However ingenious some of these contrivances may have been, it has been found that the cost of electricity to be thus utilized was so enormous, that on the score of economy, most, if not all of them have been abandoned, and finally found their way to the receptacles for the curiosities of science. The experiments of Prof. Page in this direction are still fresh in the recollection of the scientific mind; but, with his well-known knowledge of the law of equivalents, it seems strange that, depending upon the source he did for his electricity, he could not have foreseen the failure of his electric-motor. It is said, in fact, that upon the occasion of a public exhibition of this invention in Washington, it ran only a few yards and suddenly came to a full stop. All the coaxing in the world could not prevail on it to move another inch; but when an examination of the battery was made, it was found to be entirely exhausted; or, in other words, so much zinc, platinum and sulphuric acid had been consumed, that in point of economy it would have been cheaper to have burned wood or coal in the furnace of a steam-engine.

The same difficulties would be in the way of utilizing electricity as a heating agent provided a chemical battery had to be relied upon; for even if a current is sent through a small wire so as to evolve any considerable amount of heat, the battery is rapidly exhausted. With a knowledge of these facts, then, it would be hopeless to expect any satisfactory results by the employment of chemical electricity for heating purposes; but fortunately there is another kind that can be made available, as it has been demonstrated by actual experiment that a properly organized magneto-electric machine furnishes a current admirably adapted for this purpose; and moreover, what is of great importance, it is uniform as long as the instrument is operated at the same rate of speed.

Electricians are aware of the fact that by a modification of the *helices*, magneto-electric machines may be made to produce a current of either *quantity* or *intensity;* that from the former possessing great heating power and producing scarcely any shock, while that from the latter has very little heating power; but the shock from a powerful instrument would be fatal to animal life.

But it is with the *quantity* current that the writer has to deal, and he proposes to show how it may be made available for heating purposes; but before doing so a description of the "electro-heating apparatus" will be necessary.

The main feature of the invention is, that it consists of a chain or coil made up of alternate obstructions and free conductors. It is based upon the fact that electricity, in passing through a conductor of insufficient capacity (such for instance as a small wire) develops heat. If, however, the attempt is made to heat any considerable length of wire it will be melted, for the reason that heat increases the non-conductivity of it, or, in other words, increases the resistance. Now, by this arrangement of alternate obstructions and free conductors, it has been found that a powerful current of electricity may be sent through *any length* of the chain, and the result is, that though the tendency of the current may be to produce incandescence in the obstructing intervals, the heat is so rapidly taken up by the larger pieces of metal or radiators, that this is prevented entirely. In the experiments of the writer he has employed for the obstructing intervals, platinum wire one-hundredth of an inch diameter, and for the radiators, pieces of copper of about one-eighth of an inch. These radiators also perform the part of reservoirs so as to produce an equal distribution of the current; and hence when a sufficiently powerful current is sent through any length of the chain, the same caloric effects are produced in every portion of it, which fact has been fully demonstrated by actual experiments with the Wilde magneto-electric machine, in charge of the Engineer Bureau in Washington.

Now, it is simply by arranging this

chain in a compact form that sufficient heat may be accumulated for practical purposes.

For the purpose of heating railway cars it is proposed to place a heater, in the form of a metallic plate, in front of each seat so that the feet of passengers may rest on them ; and it is supposed that the heat radiated from 25 or 30 of these plates would, by heating the lower strata of air (which is never accomplished by stoves), produce in the body of the car a comfortable temperature.

Admitting, then, for the present, that the principles upon which this invention is based are sound, and also, if a current of electricity is furnished these results will be produced, the next inquiry would be as to the source from which the electricity is to be obtained. This inquiry can be answered by stating that in applying the invention to cars, it is proposed to employ a magneto-electric machine, placed under the car, and obtain the power to operate it from the axle.

In the face of a statement of a so-called "expert" to the effect that the current from a magnet machine possessed no heating power whatever, the instrument which has been referred to in another place, will heat to redness over 20 ft. of No. 20 iron wire ; and, in fact, it is estimated that it possesses a heating power equal to *ten times* that of the enormous battery in the Capitol building in Washington, which is composed of 164 cells, as large as an ordinary wooden bucket.

The heating power of magneto-electric machines being established and admitted, the next inquiry would be as to the economical application of them. "What is the cost of them, and what power is necessary to operate them?" some one is supposed to have inquired.

By means of another invention of the writer's, which he has termed a "circuit-changer," very large machines may be dispensed with entirely ; and of course the smaller the machine the less it would cost and the less power it would require to operate it. This instrument consists of a revolving shaft or barrel, one end of which is kept in constant connection with the battery or machine, by means of a brake. Placed on the shaft are a number of points arranged spirally, so that in revolving the instrument no two points approach the same line at the same time. Corresponding to these points are springs, and when the apparatus is in operation each point is brought consecutively in contact with corresponding springs. To give a better idea of the contrivance, it might be compared to a musical box, the difference being that in revolving it a *contact* is made instead of a musical sound. By means of this instrument a current of electricity may be sent consecutively through as many different circuits as there are points on the cylinder, the only limit being the number of the latter that can be placed on a cylinder of a certain length and diameter. It is easy to understand, therefore, if a current of electricity of a certain power will produce certain calorific effects by being sent through a certain circuit at the rate of, say 500 times in a minute, it would produce the same effects by being sent through any other, or 100 more, for the reason that the same current is sent through each different circuit the same number of times per minute ; and but for the wear which it would necessarily entail on the instrument, it could be revolved with such rapidity as to make it in each very nearly continuous.

In order to warm a railway car, then, it would require a circuit-changer with points on it corresponding to the number of seats ; and if a passenger should find the heat under his feet uncomfortable, he could easily, by a contrivance for the purpose, cut off the current, and at once cause an abatement of it.

The writer does not pretend to assert that this method of producing heat is actually cheaper than the combustion of wood or coal in stoves ; but in its application to cars he contends that it would certainly be safe ; for in case of a train being thrown from the track, instead of being roasted alive by a red hot stove, a passenger, escaping the perils of the wreck, might escape with his life. But the whole question of its economical application, however, is simply narrowed down to what power it would require of the axle of a car to operate a magneto-electric machine, and what, if any, additional fuel it would require to be burned in the locomotive to compensate for it. There might be differences of opinion on this point, but practical railroad men assert it frequently happens that, by some carelessness of the brakesman, more resistance to the progress of the train is

created by not raising the brakes of some particular car, than would be produced by operating a sufficient number of machines to warm an entire train. As bearing on this point also, Prof. Bartlett, of West Point, says:

"It is very certain that of two cars in all other things equal, one having your apparatus and the other not, that the latter must run the faster, and just by the difference of velocity due to the power necessary to give motion to your magnets.

"But you need not give yourself any troubles in this direction. There will always be power enough in a properly constructed locomotive to give sufficient speed to a train and turn your apparatus also."

Mr. M. F. Maury, Jr., also says, in substantiation of these views:

"The power of a loaded passenger car running at express speed is 7 H. P. A £90 magneto-electric machine takes 1 H. P. to work it. Therefore, in applying your invention to heating cars, you can, as you propose, easily derive the working power from the axle of the car."

But it is not only in railroad cars that electro-heating may be advantageously used; in factories, machine shops, or wherever a cheap motive power exists, it may be employed to great advantage.

MINERAL RESOURCES OF RUSSIAN TURKESTAN.

From "The Engineer."

The annexed observations upon the mineral resources of the newly acquired Russian territories in Central Asia are extracted from a recently published work, "Pashino's Turkestan in the Year 1866." The author visited the newly-occupied territory in an official capacity shortly after the capture of Tashkend, but the compilation of his work was deferred through a variety of circumstances until the close of the year 1868; his observations professedly embrace the result of the explorations which had been made up to the latter date, and consequently are more recent than those contained in other works which have appeared in an English or German dress.

M. Pashino remarks that "the Russian Government has entertained great expectations of the wealth of its new possessions, and it can only be hoped that its anticipations may not be disappointed. Later and more minute inquiries respecting the mineral resources of the country, and the prospects of finding gold there have not tended to confirm the reports of earlier writers." The evidence, however, is only negative; and, bearing in mind the undeveloped condition of most of our own colonies, it would appear unfair to attach overmuch weight to these avowedly incomplete investigations.

He gives a summary of the latest inquiries up to the date of his work as follows:—

Colonel Tartarounoff, of the Topographical Engineers, who was specially deputed to examine into and report upon the probable supply of coal, discovered a bed of that mineral 9 ft. in thickness on the banks of the river Bogon, but situated at such a depth below the surface as to render its profitable working very problematical. Another bed, not as yet explored, has been found on the banks of the Karatchak, ten versts from Turkestana, and thirty versts from the Syr Daria.

A rich lead vein was discovered by a certain M. P——on the banks of the Tourlan-Azi, on the road from Turkestana to Tchoulak-Kurgan. Also a bed of steam coal near Yesendi-Boulak.

Of the coal nothing is known; but the lead, it would seem, is worth working. The vein yields 76 per cent. of ore, with 5 lbs. to 6 lbs. of silver in each pood (40 lbs.) of lead.

Explorations in search of gold were made by the late M. Koleben, of the Topographical Engineers, by M. Perveshon, by a wealthy native gentleman residing in Tashkend, Said Azim, and by others. No traces of gold were discovered by the two explorers first named. According to the reports of some of the others it was observed in ten places on the banks of the Tchourtchouk, and Tchatkali, the latter being a small mountain stream distant about seventy versts from Tashkend, and of which the first-named stream is the prolongation.

M. Pashino observes that it is very difficult to ascertain the extent of the re-

sources of the country in this respect, inasmuch as the auriferous strata are overlaid by a bed of peat, in some places of nine to twelve sajens (60 ft. to 80 ft.) in thickness. The obstacles in the way of "prospecting" were, he thinks, the cause of the failure of the explorations made by the Topographical Engineers. At the same time he is disposed to believe that the alluring reports of the wealth of the gold deposits along the banks of the Syr Daria, which were published abroad long since, may have originated in part in the vain-glorious garrulity of Asiatics desirous of exaggerating the wealth of their native land.

"It is reported," he says, "that immediately previous to the Russian occupation of the country gold dust was sold secretly in the bazaar at Tashkend for seven roubles the zolotneek, but that since it has been smuggled from Russia the price has fallen to four roubles. This appears probable. Places have been found beneath the peat, excavated to a depth of one or two sajens, from whence, according to the natives, the dust was extracted without the cognizance of their rulers. By these accounts the dust was sifted in horse-hair bags, and disposed of privately in the nearest bazaar. Other reports fully confirm the belief that gold was thus found, and that the chief impediment now lies in digging for it." It would seem that the practice has been discontinued since the advent of the Russians; but the anticipated profits have induced the Russian Government to take prospective measures for imposing a tax on such operations.

Of the amount of silver found in the country M. Pashino has no information. It is the most extensively used of the precious metals, being employed for various articles of women's attire, necklaces, bracelets, earrings, studs, etc., for horse-furniture, buckles, breast-plates, and the like, and for ornaments to scabbards, sword belts, etc.

Turkestan is rich in indications of iron, such as are usually found in the vicinity of the coal measures.

The iron used for manufacturing purposes is imported *viâ* the Steppes, from Russia or from Persia. Thanks to the judicious policy of the Asiatic Governments, who have allowed the importation of metals duty free, it sells after its long journey, at 5 to 6 roubles per pood; that is to say, exclusive of carriage, at 3.50 to 4 roubles per 40 lbs. weight. Much of the iron brought from Russia is imported in a manufactured state.

Copper occurs in the neighborhood of the river Kelessy. Indications of its existence are also found at certain points on the left bank of the river (Syr Daria). Gems and precious stones are sold in the bazaars, but rarely and in small quantities. In all cases they appear to be of foreign importation. Amethysts, rubies and turquoises are brought from Persia; corals and small pearls from India; rock crystal, carnelians, and jasper from Siberia.

M. Pashino states that the natives are by no means behindhand in a desire to discover hidden wealth, but he insinuates that their efforts are usually restricted to the quest of real or imaginary hoards.

Considerable deposits of rock salt are reported by a M. Fedoroff to exist on Mount Kazi-Kurt, about forty versts from Tchemkend. Salt is also obtained by evaporation from several of the lakes, and beds of the mineral are said to occur on the hills between Pishpeck and Tokmack.

THE Leclanché cell, which is largely used in the batteries of the French telegraphic system, is thus reported on by Professor Morse: "This battery consists of a prism of carbon for its positive pole, which is surrounded by a mixture of peroxide of manganese and carbon pulverized, filling the porous jar. This jar is put into the glass jar containing a solution of sal-ammoniac; within the same glass jar and solution is a prism of amalgamated zinc, forming the negative pole. Its action is thus: On closing the circuit the sal-ammoniac is decomposed, the chlorine of the solution is absorbed by the zinc, the negative pole; while the hydrogen and the ammonia pass to the positive pole, reducing the peroxide of manganese. According to the inventor's explanation, 'the peroxide of manganese mixed with carbon being a good conductor of electricity, the system may be considered as a single fluid element, in which the positive pole is formed of an artificial metal having a great affinity for hydrogen.'"

THE copperplates of Audubon's "Birds of America" are for sale in this city.

ON THE NATURAL LAWS OF MUSCULAR EXERTION.

By W. STANLEY JEVONS.

From "Nature."

Among a multitude of profound and happy suggestions to be found in Mr. Babbage's "Economy of Manufacture," are some remarks on the relation between fatigue and the rapidity or degree of muscular exertion. Coulomb, it appears, had previously investigated the most favorable load for a porter, and had ascertained by experiment that a man walking upstairs without any load, and raising his burden by means of his own weight in descending, could do as much work in one day as 4 men employed in the ordinary way with the most favorable load. Mr. Babbage clearly points out (p. 30) that the exertion necessary to accomplish any kind of work consists partly of that necessary to move a limb of the body, and partly of the force actuallyutilized in the work. The heavier the work done, the larger the proportion, therefore, of the power utilized. But there is a limit to this mode of increasing the useful effect, because, by the natural constitution of the muscles, they can only develop a limited amount of force in a given time, and the fatigue rapidly increases with the intensity and rapidity of exertion. Hence there is in every kind of work a point of maximum efficiency, which is in practice ascertained more or less exactly by frequent trial.

This subject appeared to me to possess interest for at least two reasons: it might be made to throw some light upon the chemical and physiological conditions of muscular force; it might also point out how we could make some commencement, however humble, of defining the mathematical relations upon which the science of economy is founded. I have therefore attempted to add precision and certainty to the ideas put forth by Coulomb and Babbage, by some experiments of a simple kind.

The first and least interesting series of experiments consisted in ascertaining the comparative distances to which various weights could be thrown upon level ground. The product of the weight and distance was taken as the measure of useful work, and it was the object to ascertain according to what law this varied, and at what point it was a maximum. The weights employed varied from ½ lb. up to 56 lbs., and were thrown as nearly as possible in a uniform manner and at the most advantageous angle. About 57 experiments at different times were made with each weight, or 456 experiments in all; and it was quite obvious that good average results were obtained, the correspondence of different sets being very satisfactory. The results are as below:

Weight in lbs.	Average distance thrown in ft.
56	1.84
28	3.70
14	6.86
7	10.56
4	14.61
2	18.65
1	23.50
½	27.15

A little consideration showed it to be probable that these numbers would agree with an equation of the form—

$$x = \frac{p}{w + q}$$

in which x = distance thrown,
w = weight thrown,
q = constant weight representing about half that of the arm,
p = constant amount of force exerted.

The experiments give us eight distinct equations by which to determine the two unknown quantities p and q; and by the method of least squares we determine their most probable values to be—

$$p = 115.7$$
$$q = 3.9$$

The formula thus becomes—

$$x = \frac{115.7}{w + 3.9}$$

And calculating thence the distances for the several weights, they are:—

Weights.	Calculated distances.	Difference from experiment.
56	1.93	+.09
28	3.63	−.07
14	6.46	−.40
7	10.61	+.05
4	14.65	+.04
2	19.61	+.96
1	23.61	+.56
½	26.30	−.85

The correspondence is so close as to show that the formula is in all probability the true one, and the quantity 3.9 does not differ much from half the weight of

the arm, which might be expected to enter into the question. The fact is that the correspondence is embarrassingly close, and I am inclined to attribute it partly to chance. The experiments could hardly have been expected to give results accurate to an inch or two in some cases, and though the formula must be considered true on the ground of experiment, I do not quite see how to explain it on mechanical principles.

If we regard the useful effect as the moving of the greatest amount of matter, it is $x \times w$, and, theoretically speaking, increases continually with w. For the different weights and calculated distances, it is as follows :—

Weight.	Useful effect.
56	108.1
28	101.6
14	90.4
7	74.3
4	58.6
2	39.2
1	23.6
½	13.2

But in reality it was not possible to raise the larger weights without exerting additional force unconsidered in the formula, so that the practical maximum of efficiency is probably about 28 lbs., in the case of my own right arm. With different people it would, of course, vary somewhat.

The above experiments completely confirmed Mr. Babbage's remarks, but did not seem to lead to any further results. I proceeded, therefore, to other experiments upon the rate of exhaustion of muscular fibre. One mode of trial was to raise and lower various weights by a pulley and cord through the convenient range of the arm, continuing the motion with unrelaxed rapidity until the power of the muscles was entirely exhausted. The results of more than fifty experiments were as follows :—

Weight lifted.	Average number of times.	Useful effect.
56	5.7	319
42	11.9	500
28	23.0	644
21	37.6	790
14	110.0	1554

These numbers show that the total greatest amount of labor can be done with small rather than large wheels in this case ; but they fail to give any regular law, owing probably to the weight of the body being brought into use with the larger weights.

The mode ultimately adopted was to hold out various weights in the hand at the full stretch of the arm, and to observe the times during which they could be supported. No two experiments were made with the same arm, without allowing, at least, one hour to elapse, so that the vigor of the muscles might be restored. With the smaller weights there was naturally some uncertainty as to the time, but in the case of the large ones the time was very definite. Altogether 238 experiments were made, an equal number with each arm. Uniting all the experiments for the same weight, the results are :—

Weight.	Times in seconds.
18	14.8
14	32.5
10	60.3
7	87.4
4	147.9
2	218.9
1	321.2

These results are pretty satisfactory averages ; thus the probable error, for two cases indifferently chosen, was, for 18 lbs. in the left hand about .5, and for 4 lbs. in the right 2.7, and the error of the combined results would be less. With the exception of the results for 10 lbs. in the left arm, which appear to be somewhat in excess, these numbers are very regular, and point to a systematic law governing the rate of fatigue. The useful effect, or the product of the weight and time, shows a decided maximum, about 7 lbs., as follows :—

Weight.	Useful effect.
18	266
14	455
10	603
7	612
4	592
2	438
1	321

If the weight held be very small, much power is lost in merely sustaining the arm ; if the weight is large, there is comparatively little loss on that account, but the power of the muscles is soon run out, and no sufficient opportunity for restoration is allowed. The weights chosen for dumb-bells and other gymnastic exercises appear to be about those which give the maximum efficiency.

I have made several attempts to explain these numbers by reasonable suppositions as to the conditions of exhaustion and restoration of muscular power. It seemed reasonable to suppose that the supply of

new matter from the blood would increase in some proportion to the vacancy or want of it, but all such conditions led to integrals of a logarithmic form, which could not be easily compared with experimental results. No formula that I obtained could be made to agree properly with the figures, and all that can be said is that the curve representing the results has a certain appearance of a logarithmic character, so far agreeing with the formulas obtained. Those who are acquainted with the physiology of the subject might succeed better; I am not sure, for instance, how far the failure of strength is due to the exhaustion of the original substance of the muscle, how far to the inadequacy of the current supply of blood. It is a question again how far in any case of muscular action the supply is promoted by the increased action of the heart, or checked by the possible constriction of the arteries. If these questions have not been or cannot be otherwise decided, they might, perhaps, be indirectly solved by experiments of the kind described.

My own object, however, was not to intrude into the domain of physiology, but to show that definiteness might possibly be given by degrees to some of the principles and laws which form the basis of the science of political economy. In some speculations upon the mathematical theory which must underlie that science (read at the British Association in 1862, and published in the Journal of the Statistical Society for June, 1866, p. 282), I endeavored to show that it was only the the excessive difficulty of determining the character of the functions involved, which prevented economy from taking the mathematical form and standing proper to it. There is little doubt as to the principles of the subject; but when we try to put them into figures, the data are found to be so deficient, complicated, variable, and subject to disturbances of all kinds, that any hope of accuracy soon dies away in most cases. In the above experiments I have attempted to determine the exact character of the functions connecting the amount of work done with the intensity and duration of labor in certain simple cases. These cases, however unimportant in themselves, represent principles which have innumerable applications in common life.

THE DECAY OF STONE.

From "Engineering."

The recommendation of Mr. E. M. Barry, the architect of the Houses of Parliament, and of Mr. F. A. Abel, the well-known chemist of the War Department, to attempt the arrest of decay in the stone-work of the Westminster Palace, has just been produced in a report, ordered to be printed by the House of Commons. This recommendation is—oil. To cover the walls of the building, to saturate its tracery, and to soak its sculptured frontage, is the process suggested by these gentlemen. A process ancient and inefficient, one that has long been superseded by other less imperfect though crude methods, which in their turn have given place to the more recent and scientific methods. The fact is that a less satisfactory means of preserving stone could hardly have been proposed, and the wonder is that such men as Messrs. Barry and Abel should have been so short of resources that they could recommend nothing more efficient. Not only would oil be difficult of application, but, perishable as it is, it would quickly change its nature, oxidize, and thicken, until it attracted the floating impurities in the atmosphere, and would only conceal the hastening work of decay. Without advancing to the present time, more suitable remedies might have been offered for consideration; soft soap and alum would have been better, so would wax; while paraffine carefully applied would have answered best of all. But the time is past for prescriptions such as these, and the successful method devised by Mr. F. Ransome affords a rapid and effectual means of successfully preserving the stone, hitherto a thing never accomplished. We have already alluded to this process, and it is known that when it has been used good results have always followed. As is well known, it consists in the successive application of three solutions, the first containing soluble phosphate of lime; the second, baryta; and the third a solu-

tion of silicate of potash, rendered neutral by the late Professor Graham's well-known process of dialysis. These solutions successively applied, combine and form an insoluble and imperishable mineral compound, which effectually resists the action of the atmosphere, and by indurating the stone at once arrests its disintegration. The extensive experience which has been gained by the adoption of this method, places it far beyond the region of experiment, and justifies its recommendation under nearly all circumstances. And there can be no reason why, successful in every case hitherto, it should fail if it were properly applied to the failing stone work at Westminster.

That the Ransome, or some such analogous process will have to be adopted for the preservation of many of our metropolitan public buildings is certain. From a variety of causes independently of that of age, some of our finest structures are yielding to the insidious attacks of impure atmosphere and impure rainfall. The same forces of nature ever at work destroying one combination to gain the material wherewith to rear up another, and which slowly and constantly disintegrate and crumble rocks, blending them indistinguishably with the soil, is fortified by the powerful allies, called into existence by the never-ceasing necessities of the metropolis, and wears out the stones employed in our buildings, with a rapidity dependent upon the class of material upon which the forces act.

Limestone, if containing magnesia, attacked by the sulphurous acid laden atmosphere, effloresces quickly with a soluble sulphate of magnesia. If it hold carbonate of lime only, the same agent rapidly produces soluble crystals of sulphate of lime.

Sandstone again is destroyed because the action of the atmosphere rapidly changes the insoluble calcareous cement which binds the particles together into a soluble form, and the whole material crumbles when its cement is thus destroyed. And while the air charged with the destructive agents is a never-ceasing and perpetual enemy, the impregnated rain water is not only formidable from the same cause, but is formed into a force more actually dangerous because its effects are intensified and localized, as evidenced by the ruin it produces in many public buildings, in places exposed to its concentrated influence. Not only, indeed, does the rain water wash away by degrees the soluble portion of stone changed by the atmosphere, but, containing within itself the elements of destruction, it forms a more active agent which can be resisted only by rendering the stone impervious to its action. And this can only be done by indurating the material so that it may be enabled to set the opposing elements at defiance, which neither oil nor any of the old-fashioned mechanical or chemical appliances of the past are able to effect.

THE quantities of materials stated to have been used in the construction of the Thames Embankment, lately opened, are as follows :—Granite, 650,000 cubic ft. ; brickwork, 80,000 cubic yds. ; concrete, 140,000 cubic yds. ; timber (for cofferdam, etc.), 500,000 cubic ft. ; caissons (for ditto), 2,500 tons ; earth filling, 1,000,000 cubic yds. ; excavation, 144,000 cubic yds. ; York paving, 125,000 superficial ft. ; broken granite, 50,000 superficial yds.

SOME French photographers are recommending chloride of aluminium for salting paper, instead of the chlorides of sodium and ammonium generally used at present. The chief advantage of using this salt appears to be that the image is retained well on the surface, and that consequently the details in the shadows of the print are better rendered.

THE new iron hydraulic gun carriage invented by Colonel H. Clerk, Royal Artillery, F. R. S., superintendent of the Royal Carriage Department, Royal Arsenal, Woolwich, has been completed and fitted up in the Government marshes at Woolwich for experimental purposes. The gun is specially designed for use in the Royal Navy.

NO ATTEMPT to build Government offices on the Thames Embankment will be made this year, and before any such attempt is made at any future time Parliament is to have full opportunity to discuss the matter.

ON THE CALCULATION OF EXCAVATION AND EMBANKMENT TABLES FOR THE USE OF RAILROAD ENGINEERS.

By WM. H. GRIFFIN, C. E.

Engineers frequently find themselves, when in the employment of a new company, in want of tables, adapted to such bases and slopes as are not contained in any published tables. The following expeditious and easy method of calculating earth-work tables has been familiar to the writer for more than twenty years, and it is believed is now published for the first time.

As a preliminary to the method, I will take the following equation :

$$y = a x^m + b x^{m-1} + c x^{m-2} + \ldots + p x + q,$$

and explain that if we give to x a succession of values, increasing according to an arithmetical progression, the values of y will increase according to a law which is easily ascertained. If we give, in the foregoing equation, to x successively the values 0, 1, 2, 3, 4, etc., we shall ascertain the corresponding values of y. Then, taking the differences of the values of y, we will obtain the first order of differences, generally designated D_1. Then, taking the differences of the differences, we will obtain the second order, designated D_2. And again, by taking the differences of the second order we obtain a third order, and of the third order a fourth, and so on, until an order is finally arrived at that is constant. If m represents the highest exponent of the equation, then the mth order of differences will be constant. An equation of the fifth power giving five orders; one of the fourth power four orders; a cubic equation three orders, and a quadratic equation two orders.

Upon the above principles, let it be required to calculate an excavation table, for a base of twenty feet, with slopes of three-quarters to one, and for one hundred feet lengths. Let y represent the cubical contents in yards, and x the depth of cutting in feet and tenths of feet. Then we shall have this equation:

$$y = \frac{100}{27}(20 + \tfrac{3}{4}x)x = \frac{100}{27}(20x + \tfrac{3}{4}x^2) =$$
$$3.703\,(20x + \tfrac{3}{4}x^2 = 74.074\,x + 2.777\,x^2.$$

Now give to x a regular succession of values, as 0, 1, 2, 3, etc., and we will have

For $x = 0$, $y = 0$.
For $x = 1$, $y = 76.851,851$.
For $x = 2$, $y = 159.259,259$.
For $x = 3$, $y = 247.222,222$.
For $x = 4$, $y = 340.740,740$.

Take the differences of these values of y and the differences of the differences, and we will have :

D_1	D_2
76.581,851	
	5.555.555.
82.407,407	
	5.555,555.
87.962,962	
	5.555,555.
93.518,518.	

We now rule four columns, designated respectively x, y, D_1 and D_2, and having inserted the figures already ascertained, we will add the figures in column D_2 to the previous ones in column D_1 and then those in column D_1 to the previous ones in column y, and will thus ascertain the value of y, for the corresponding value of x, or the cubical contents, for the particular depth.

x	y	D_1	D_2
0	0		
1	76.851,851,851	76.851,851,851	5 555,555,555
2	159.259,259,259	82.407,407,407	5.555,555,555
3	247.222,222,222	87.962,962,962	
4	340.740,740,740	93.518,518,518	
5	439.814,814,814	99.074,074,074	
6	544.444,444,444	104,629,629,629	
7	654.629,629,629	110.185,185,185	
8	770.370,370,370	115.740,740,740	
9	891.666,666,666	121.296,296,296	
10	1018.518,518,518	126.851,851,851	
11	1150.925,925,925	132.407,407,407	
12	1288.888,888,888	137.962,962,962	
13	1432.407,407,407	143.518,518,518	

In this way we can continue the table to any depth that may be required. If we notice the figures of the decimals in column D_1, we shall see that they are repeated for every ninth foot. This is as it should be, for 5.555 multiplied by 9 is equal to 50,000. Therefore, after the first ten feet, the calculation is proceeded with with much less trouble and difficulty.

To make the calculation by tenths of feet. First find the orders of differences by substituting for x, in the foregoing

equation, the values 0, 0.1, 0.2, 0.3 0.4, and the following results are obtained:

		D_1	D_2
For $x=$	$0-y=0.$		
For $x=0.1-y=$	7.435,185	7.435,185	
For $x=0.2-y=$	14 925,925	7.490,740	0.055,555
For $x=0.3-y=$	22.472.222	7.546,296	0.555,555
For $x=0\,4-y=$	30.074,074	7.601,851	

Four columns are now again ruled, and we then proceed in the same manner as for whole feet.

a	y	D_1	D_2
0	0		
0.1	7.435,185,185	7.435,185,185	
0.2	14.925,925,925	7.490,740,740	0.055,555,555
0.3	22.472,222,222	7.546,296,296	0.055,555,555
0.4	30.074,074,074	7.601,851,851	
0.5	37.731,481,481	7.657,407,407	
0.6	45.444,444,444	7.712,962,962	
0.7	53.212,962,962	7.768,518,518	
0.8	61.037,037,037	7.824,074,074	
0.9	68.916,666,666	7.879,629,629	
1.0	76,851,851,851	7.935,185,185	
1.1	84.842,592,592	7.990,740,740	
1.2	92.888,888,888	8.046,296,296	
1 3	100.990,740,740	8.101,851,851	
1 4	109.148,148,148	8.157,407,407	
1 5	117.361,111,111	8.212,962,962	
1 6	125.629,629,629	8.268,518,518	
1.7	133.953,703,708	8.324,074,074	
1 8	142.333,333,333	8.379,629,629	
1.9	150.768,518,518	8.435,185,185	
2.0	159.259,259,259	8.490,740,740	

We observe that the decimals again repeat themselves in column D_1, for every ninth foot.

In calculating earth-work tables, after the method here set forth, the calculations should always be made separately, for the whole feet and tenths of feet. The one will be a check on the other, and consequently any error in the figuring will be readily detected.

If one should desire to calculate earth-work, for final estimates, with the same accuracy as by the prismoidal formula, it can be done with the tables calculated as the foregoing, and with much more expedition. It is only necessary to add the cubical contents for each end-depth to four times that for the average depth, and then take one-sixth of the sum, and the same result is obtained as the prismoidal formula would give.

Suppose, for instance, that we should desire to know the amount of excavation for a cutting 100 feet long, and one foot deep at one end and nine feet at the other.

The foregoing table gives:—

For 1 ft.....	76.853 cu. yards.
For 9 ft.....	891.666 "
For 5 ft. 439.814 c. yds., which mutiplied by 4 = ...1759.259	"
Amount..... .....2727.777	"

One-sixth of which is 454.629 cubic yards; exactly the same result as given by the Prismoidal Formula.

For approximate estimates we can merely average the cubical contents for each end depth, or take the cubical contents for the average depth—the former giving too much and the latter too little.

Take the last amount again.

The Prismoidal Formula gives..454.629 cu. yards.	
The average depths give 439.814	"
The average cubical contents give.....484.259	"

The average depth giving 24.814 yards too little, and the average contents 44.444 yards too much.

In order to show that the law of the differences holds good, for cubic equations, as well as for quadrature, I will take the following:

$$y = x^3 + 2x^2 + 3x + 4$$

Now give to x, in succession the several values, 0, 1, 2, 3, etc., and arrange a table as before.

x	y	D_1	D_2	D_3
0	4			
		6		
1	10		10	
		16		6
2	26		16	
		32		6
3	58		22	
		54		
4	112		28	
		82		
5	194		34	
		116		
6	310		40	
		156		
7	466		46	
		202		
8	668		52	
		254		
9	922		58	
		312		
10	1234		64	
		376		
11	1610		70	
		446		
12	2056		76	
		522		
13	2578		82	
		604		
14	3182		88	
		692		
15	3874			

THE splendid new steamer Scandinavian, of the Allan line of mail steamers, left Quebec at noon on the 9th July last, and arrived at Liverpool at 6.40 A. M. on the 18th. Thus the time occupied in the run to Liverpool was 8 days, 13 hours, and 55 minutes. This is the quickest passage ever made between Quebec and Liverpool.

THE GREAT TRIGONOMETRICAL SURVEY OF INDIA.

From "The Engineer."

The Indian Survey Department, under the direction of the superintendent of the Great Trigonometrical Survey, and of the Surveyor-General of India, comprises three distinct branches, viz.: the Great Trigonometrical, the Revenue, and the Topographical Surveys, each of which has a separate staff of superintending and executive officers. The operations of the Great Trigonometrical branch of the department are essentially scientific, and of the highest order of geodetic undertakings, and form the basis of the geographical maps of India; its subjects are similar to those of the great national scientific surveys undertaken in other parts of the world for the determination of the figure of the earth and the three co-ordinates of latitude, longitude, and elevation. It is under the more immediate control of a superintendent, whose head-quarters are at Dehra Dhoon, at the foot of the Mussoorie Hills, and is composed of a staff of 24 officers and 46 assistants. This staff is divided at present into 15 parties of varying strength, which are scattered over India, and are employed in trigonometrical, topographical, geodetic, astronomical, and levelling operations, as well as geographical explorations beyond the frontiers of British India. The trigonometrical operations comprise the primary and secondary triangulation, and the measurement of base lines for their verification.

The Revenue Survey branch, in the Bengal Presidency, extends its operations into such parts of the country as are under British administration, and yield a fair revenue. It is the most extensive branch of the department, and to insure proper supervision has been placed under two superintendents, each of whom has a distinct circle of control; the head-quarters of both being at Calcutta. The entire staff consists of two superintendents, 31 military and civil officers, and 73 assistants, with a large addition of subordinate native agency.

The Topographical branch of the Indian Survey Department is under the immediate superintendence of the Surveyor-General of India, whose head-quarters are at Calcutta. The staff consists of 15 military and civil officers, and 49 assistants, with a small number of native surveyors and draughtsmen, divided into 7 parties, employed in various parts of Upper and Central India. The Topographical Survey operates chiefly in hilly and jungle-covered ground, yielding but little revenue in parts of the country not actually under British management, and in friendly native states along the British frontier. Its object is to obtain a cheap, rapid, and reliable first survey for geographical and administrative purposes.

The Trigonometrical Survey, which at the present time extends from Cape Comorin to Thibet, and from the meridian of Calcutta to that of Cashmere, was commenced at the beginning of the present century by the late Colonel Lambton. That officer, who had previously served as a surveyor in America, joined her Majesty's 33d regiment, at Calcutta, in the year 1797. Professor Airy, in his report on Astronomy presented to the British Association in 1832, stated that, at the beginning of the century, an arc was measured "in India by Reuben Burrows." Of this, however, we have been unable to find any confirmation; Mr. Burrows did make many observations of latitudes and longitudes of places in Bengal, which were more accurate than any others previously determined, a list of which was published in the "Asiatic Researches," but no account is to be found of any operations by him for the measurement of an arc of the meridian.

Immediately after the fall of Seringapatam, and the successful termination of the war with Tippoo, Captain Lambton brought forward his plan of a geographical survey of part of the peninsula of India. This work subsequently became the nucleus of the Great Trigonometrical Survey; but the first idea was much more circumscribed, and was confined to throwing a series of triangles across from Madras to the opposite coast, for the purpose of determining the breadth of the peninsula in that latitude, and fixing the latitudes and longitudes of a great many important places, the geography of which was supposed to be very erroneous. This

plan was, in the year 1800, submitted to Government, with the recommendation of the Duke of Wellington, to whose cordial support the Trigonometrical Survey of India owes its origin. Lord Clive was at that time Governor of Madras, and warmly approved of the undertaking, which was accordingly sanctioned by Government. Instruments were forthwith ordered from England, and in the interim a preliminary survey was made of that part of Mysore extending from the Eastern Ghauts to Seringapatam and Perah westerly, and to Baggapilly northerly, taking in some points within the ceded districts. The instruments used in Colonel Lambton's operations were a 36 in. theodolite by Cary; an 18 in. repeating theodolite by the same maker; a 5 ft. zenith sector by Ramsden; two steel chains by the same maker; a standard brass scale by Cary; and several small theodolites by different makers, for minor purposes. These instruments were the finest that the state of art at the commencement of the present century could produce. The great theodolite received an injury in the year 1808, while it was being hoisted to the summit of a lofty pagoda in Tanjore, and it was repaired by Colonel Lambton himself, who, to the duties of an astronomer and surveyor, had, throughout his operations, to combine those of a mathematical instrument maker. Colonel Everest, in an account published by him in 1830, of the measurement of an arc of the meridian, etc., states that "in the commencement of the Great Trigonometrical Survey in 1799 one steel chain by Ramsden was the only measuring apparatus. The history of this was rather singular. It had been sent with Lord Macartney's embassy as a present to the Emperor of China, and, having been refused by that potentate, it was made over by his Lordship to the astronomer, Dr. Dinwiddie, who brought it to Calcutta for sale, together with a zenith sector (a beautiful instrument, *for that time*, by Ramsden). The purchase of both was made by Lord Clive, the Governor of Madras, at the instance of the Earl of Mornington, Governor-General of India." The work of measuring a base line was commenced on the 10th April, 1802, on a plane near St. Thomas Mount, Madras, at no great distance from the shore, and nearly on the level of the sea. The length of the base, reduced to the level of the sea, and to the temperature of 62 deg., is 40,006.44 ft., or 7.546 miles; the latitude of the north end was 13 deg. 00 min. 29 sec., and it made an angle of little more than 12 min. with the meridian. Captain Lambton used a chain similar to one already employed by General Roy on the Ordnance Survey in England. It was made of blistered steel, in 40 links of $2\frac{1}{2}$ ft. each. The chain was laid in coffers or long boxes, supported on stout pickets driven into the ground, and their heads dressed even by means of a telescope. At one end of the chain was the draw-post, to the head of which the near end of the chain being fastened, could be moved a little backwards or forwards by means of a finger-screw. Near the handle of the chain, and at the point where its measuring length was supposed to commence, there was a brass scale with divisions, which was fixed to the head of another picket, distinct both from the draw-post and from those supporting the coffers. This scale could, by means of a screw, be moved backwards and forwards on the head of the post, till it coincided with the mark on the chain. A similar arrangement was made at the other end, but the handle of the chain, instead of being firmly attached to the *weigh* post, as it is called, had a rope passing over a pulley; and to this rope was appended a weight of 28 lbs., to keep the chain stretched. This arrangement enabled the measurer to move his chain backwards and forwards with the greatest nicety, and, when satisfied that it was correctly placed, to keep it there perfectly steady; while, by means of the registers, he marked exactly the places of the two extremities of the chain. The chain was then taken forward, and the near end being adjusted to the scale which had before marked the fore end, a new chain's length was laid off, and so on till the base was finished. Thermometers were placed in the coffers to determine the temperature of the chain; and the rate of expansion being previously determined by experiment, the necessary corrections were made for the varying temperature of the measurement. The quantity of this correction had been found to be on 100 ft. .0075 in. for every 1 deg. of Fahr.: but Captain Lambton, by some experiments previously performed with the chain, found .00725, which quan-

tity he applied as the correction of his measurement. Besides the original chain, a second was obtained from England exactly similar. Its length had been fixed in the temperature of 50 deg. This chain was preserved as the standard, and to its indications were reduced all the measurements made with the other.

In May, 1804, a base of verification of 39,793.7 ft. was measured at Bangalore; and though the distance was nearly 160 miles, the computed and measured lengths of this base differed only 3.7 in., or about half an inch in a mile. This base was adopted for the origin of the Great Indian Arc series. From it triangles were carried across the peninsula to the opposite coast, and a meridional series was also commenced on a meridian about 35 miles west of Madras, which was subsequently abandoned for the meridian of Dodagontah, further to the west, and on which the Great Indian Arc series was gradually established from Cape Comorin up to latitude 29½ deg. north, being the largest arc yet measured on the earth's surface. Col. Lambton's operations detected an error of no less a quantity than 40 miles in the breadth of the peninsula, as previously laid down astronomically, and all the principal places on the old maps, which had been fixed astronomically, were found considerably out of position. Thus, Arcot was out 10 miles, and Hyderabad no less than 11 min. in latitude and 32 min. in longitude. The distance from Madras to the opposite coast, in the same parallel, was found to be 360 miles, very nearly; whereas the best maps, till then, had made it exceed 400 miles. The triangles were contrived so as to avoid, as much as possible, very acute and very obtuse angles, and the sides of many were from 30 to 40 miles in length. In computing the sides, Colonel Lambton reduced the observed angles to the angles of the chords, according to the method of De Lambre; and although he computed the spherical excess, he did not use it in any other way than as a measure of the accuracy of his observations. The chords, which were the sides of the triangles, were then converted into arches; and, as Major Lambton had contrived that the sides of the 4 triangles which connected the stations at the south and north extremities should lie very nearly in the direction of the meridian, their sum, with very little reduction, gave the length of the intercepted arch, which was thus found to be 95,721.326 fathoms. By a series of observations for the latitude at the extremities of this arch made with the zenith sector, the amplitude of the arch was found to be 1.58233 deg., by which, dividing the length of the arch just mentioned, Colonel Lambton obtained 60,494 fathoms for the degree of the meridian bisected by the parallel of 12 deg. 32 min. This, till the survey was extended further to the south, was the degree nearest to the equator (excepting that in Peru, almost under it) which had yet been measured, and was, on that account, extremely interesting. The next object was to measure a degree perpendicular to the meridian, in the same latitude. This degree was accordingly derived from a distance of more than 55 miles, between the stations at Carangooly and Carnatighur, nearly due east and west of one another. Very accurate measures of the angles which that line made with the meridian at its extremities were here required, and these were obtained by observations of the Polar Star when at its greatest distance from the meridian. For this purpose a lamp was lighted, or blue lights were fired, at a given station, the azimuth of which was found by the Polar Star observations, and afterwards its bearing in respect of the line in question. Thus the angle which the meridian of Carangooly makes at the pole with that of Carnatighur, or the difference of longitude of these two places, was computed. It was then easy to calculate the amplitude of the arch between them, and thence the degree perpendicular to the meridian at Carangooly was found to be 61,061 fathoms.

Between the years 1802 and 1815 Col. Lambton covered the whole country as high as 18 deg. latitude with a network of triangles, whereby the peninsula was completed from Goa on the west to Masulipatam on the east, with all the interior country, from Cape Comorin to the southern boundaries of the Nizam's and Mahratta territories. For a long period these operations were frequently interrupted by the disturbed political condition of the country, which was often the scene of warlike operations. The mysterious character of the instruments and operations, as well as the planting of flags and signals, always more or less awakened the apprehensions or excited the jealousy of native

princes, and it required, therefore, no ordinary tact, firmness, and patience on the part of the head of the department to secure good-will. The area comprised by the whole of the operations prosecuted during the time Colonel Lambton was superintendent aggregated 165,342 square miles. The expense incurred amounted to Rs. 835,377, consequently the rate at which the triangulations were executed averaged Rs. 5 0 10, or less than 10s. per square mile.

In October, 1817, the Marquis of Hastings, impressed with a well-founded conviction of the important utility of the Trigonometrical Survey, resolved to transfer the control over its operations to the Supreme Government of India; and in consideration of Colonel Lambton's increasing age and infirmities, Captain (subsequently Colonel) Everest was appointed to assist him. Captain Everest joined the appointment in 1818, and the Great Arc triangulation was subsequently extended nearly to Takal Khera, in latitude 21 deg. 6 min. The greater part of the Nizam's eastern territories was triangulated by meridional series between the Kistnah and Godavery, and considerable progress was made in the longitudinal series from the Beder base line towards Bombay. Upon Colonel Lambton's death, Captain Everest succeeded to the office of superintendent, and he immediately proceeded to concentrate all the resources at his disposal on the extension of the Great Arc series, which, after many difficulties, was at length carried up to latitude 24 deg., where a base line was measured at Seronj. Col. Everest then proceeded to England on sick leave, and during his absence a longitudinal series was extended from the Seronj base line towards Calcutta. This series was eventually brought to a close in the year 1832, at the Calcutta base line, having occupied a period of 6 years in accomplishing a direct distance of 671 miles. In 1830, Colonel Everest returned to India, liberally provided with geodetical instruments and apparatus of every description, comprising a complete base line apparatus, the invention of Colonel Colby, precisely similar to that employed on the Ordnance Survey; a great theodolite, 36 in. in diameter, designed by Troughton, to 18 in. theodolites, and a variety of smaller instruments from 12 in. diameter downwards, all of which were manufactured by Messrs Troughton and Simms. The signals, all of the most efficient kind, and recently invented, consisted of heliotropes, reverberatory lamps, and Drummond's lights, of which the two former have been exclusively used. The substitution of luminous signals for opaque ones contributed vastly to the subsequent improvement of the observations. Alterations in the departmental arrangements, official delays, and the measurement of the Calcutta base line, occupied Colonel Everest until the end of 1832, from which time the Great Arc may be considered to have actually recommenced after a cessation of 7 years. The work was carried on unremittingly till December, 1841, when the whole Indian Arc, from Cape Comorin to the Himalaya Mountains, forming the main axis of Indian geography, was finally completed.

The Calcutta base line was measured upon a broad road leading from the Government House in Calcutta to the Government Palace at Barrackpore, which immediately on emerging from the suburbs is sufficiently straight for about six miles and a half. Calcutta and its vicinity, and in fact all places in Lower Bengal, being so encumbered with lofty trees and dwelling-houses as to restrict the view to a very short distance, and as these could not be removed, there was no other mode of carrying on trigonometrical operations than by raising both ends of the geodetical line so as to overtop these obstructions. Two towers of 75 ft. high each were accordingly erected at either limit of the Calcutta base, whereby it was connected with the triangulation. This base was the first occasion on which the new compensation bars were brought into use in India.

The area comprised by the Great Arc operations, principal and secondary, aggregates 56,997 sq. miles, including the revision of the section from Beder to Kalianpoor, and the measurement of 3 base lines, each from 7½ miles to 8 miles in length, viz.: those of Beder, in latitude 18 deg.; Seronj, near Kalianpoor station, in latitude 24 deg.; and the Dehra base, about 70 miles north of Kaliana station, in latitude 29.30 deg., where the Great Arc actually terminates. On comparing the actual measurement of the Dehra Dhoon base, by Colby's apparatus, with that calculated from the Seronj base,

measured in 1824 by a chain, a difference of nearly 3½ ft. was found. Colonel Everest, justly considering the difference as indicating a much larger errror than ought to exist, resolved to re-measure the old base with the more accurate apparatus he now had at his command. This operation was completed in January, 1838, when it appeared that the length given by the chain measurement of 1824 was too short by nearly 3 ft., as compared with the new result. The Dehra Dhoon base is nearly 7½ miles in length; the ground is undulating, and by no means favorable; the line is twice intersected by the stream of the Asan, and the height above the sea level of one end of it is 186 ft. greater than at the other. The base was measured twice, first from west to east, and then in the opposite direction. After all reductions the two results were as follows: Length in feet at the level of the sea—by measurement, 39,183.97329; by the re-measurement, 39,183.77357; difference, 0.19972, corresponding to $2\frac{4}{10}$ in. nearly. Another test was applied with an equally satisfactory result. The entire line was divided into 3 sections, and the two end sections deduced from the middle one by triangulation. The discrepancies between the measured and computed distances were + 0.33 in. in the one case, and —0.078 in. in the other; so that the whole base, deduced in terms of the middle section, differed from the length actually measured by scarcely more than a quarter of an inch. The other two bases, at Seronj and Beder, were measured exactly in the same manner as that in the Dehra Dhoon. In the case of the Beder base (nearly 8 miles) the measurement was tested by dividing the whole length into three sections and computing the two end sections from the middle one by a triangulation. The difference was found to amount only to an inch in the one case, and about two-thirds of an inch in the other; the computed length exceeding the measured length in both cases.

Great importance was attached to the construction of the stations. Throughout the Doab it was necessary to erect artificial structures of sufficient height to overtop the trees, and of sufficient solidity to afford a firm support to the theodolite. These were of a very substantial kind—square towers of solid masonry, about 50 ft. in height, with walls 5 ft. in thickness at the foundation, and 2 ft. at the top. A stone slab, supported on two transverse stone beams, formed the floor on which the instrument stood; and the stage for the observers was entirely disconnected, in order to avoid vibration while the observations were going on. The centre of the station was carefully defined on a plate of metal let into a stone, and sunk in the ground for further security; and the theodolite and signals were in all cases accurately adjusted over the centre. The sites of stations were also carefully selected with a view to well-conditioned triangles. It was a general rule, steadily adhered to, that no angle of any triangle should be less than 30 deg. The sides of the triangles may be stated to be from 10 to 25 miles, and in a very few instances only are they found so much as 30 miles. In order to eliminate errors and obtain results of uniform precision, the angles were measured from 8 different zeros on the circle, the established rule being "to observe three times at each zero with the face left, and as many with the face right; then to change the zero three times by 9 deg. each time, and at each position to go through a like operation, whereby it is evident that every ninth degree will in turn fall under one or other of the microscopes." For computing the sides of the triangles, the theorem of Legendre was used with the following results: The length of the Dehra Dhoon base, brought out by computation from the Seronj base, was found to be 39,183.273 ft., and by actual measurement 39,183.873 ft., the difference being 0.600, six-tenths of a foot, or a little more than 7 in., the distance between the two bases being about 430 miles. Again, the Beder base, brought out by computation from the Seronj base, was found to be 41,578.536, the difference in this case being only 0.358 parts of a foot, or a little more than 4 in., the distance between the two bases being about 426 miles, and the calculation made through 85 principal triangles. The relative heights of the stations were determined by means of observations of their vertical angles, as seen from each other, made with 18 in. altitude and azimuth circles. For deducing the amplitude of the northern section, Seronj to Kaliana, 36 stars were selected, half of them to the south and the other half to

the north of the zeniths of both stations, but none of them having a zenith distance exceeding 5 deg. from the nearest vertical. For the southern section 32 stars were observed at Seronj and Beder.

In the year 1829 a trigonometrical survey in the Bombay Presidency was commenced by Lieutenant Shortrede on an independent base and point of departure. Finding that no use could be made of this confused net of triangulation, Colonel Everest directed, in 1831, that the longitudinal series should be taken up where he left off in 1823, at the time of Colonel Lambton's death. The Bombay longitudinal series was brought to a conclusion in 1841; it extends 315 miles in length, and occupied 12 years.

Immediately after the measurement of the Calcutta base line several parties were fitted out with the view of carrying on triangulations in different directions; but it is not our purpose here to follow each of these parties in their operations, as that would occupy too much space, and be of but little interest to most of our readers. In his report on the general state of the work up to 1850, Colonel Waugh (who had succeeded Colonel Everest as Surveyor-General of India and Superintendent of the Great Trignometrical Survey), remarking upon the accuracy attained by the modern operations, observed that in the large triangulation, where of course the greatest refinement and most scrupulous care is observed, an error of 1 in. per mile, or $\frac{1}{63360}$ part, amounts to 500 in., or 42 ft., or nearly half a second in arc of latitude or longitude in 500 miles, which distance is even exceeded between some of the bases. The work is reckoned liable to half this error when executed with the great theodolite, on the principle of double series; the results attained by the new 24 in. theodolites are but little inferior to this degree of accuracy. When the series are single, the liability to error is reckoned to approach nearer to 1 in. per mile; when performed with good 18 in. theodolites the error will exceed 1 in. per mile, according to the character of the graduation. With inferior instruments, or a less careful system, the accumulation of error would approach a foot per mile, which is equal to a ratio of $\frac{1}{5280}$ in linear dimension, or $\frac{1}{27878400}$ in area, or $\frac{1}{10}$ per cent., or six seconds of arc in the above distance.

Sir Andrew Waugh, who succeeded Colonel Everest, held the appointment of superintendent of the Great Trigonometrical Survey for 17 years, and on his retirement was succeeded by Colonel J. T. Walker, R. E., as superintendent of the Great Trigonometrical Survey, and by Colonel Thullier, R. A., as Surveyor-General of India, both which officers respectively fill those appointments at the present time.

In the principal triangulation of India a gridiron system is followed, similar to that adopted in the French and Russian surveys, consisting of chains of large triangles extending along the principal meridians and the course of the eastern and western frontier, and connected with other chains of longitudinal series, the northernmost of which follows the Northern British frontier, while the others run along certain parallels of latitude at convenient intervals. Colonel Everest's Meridional Arc, which extends from Capo Comorin to the Himalayas, over a length of upwards of 22 deg., from its central position and intrinsic value, naturally forms the axis of the system. Base lines are measured at the extremities of the longitudinal chains, and at the points where the chains cross Colonel Everest's arc. Thus the triangulation is divisible into large quadrilateral figures, with a base line at each corner. Nearly all the principal series of triangles consist of double figures (polygons or quadrilaterals) for mutual verification, and to reduce the accumulation of error to a minimum. The length of the sides of triangles in the plains is on an average about ten miles, and the greatest care is taken to obtain symmetrical figures. In hilly country the lengths of sides vary considerably. The instruments used for the principal trigonometrical operations are the great theodolites, having azimuthal circles of 24 in. to 36 in. diameter, with 5 microscopes, and vertical circles of 15 in. to 18 in. diameter, with 2 microscopes. The signals to which observations are taken are luminous—heliotropes by day and lamps by night. The secondary triangulation is conducted with vernier theodolites, having azimuthal circles of 14 in. to 8 in. diameter; the signals are both luminous and opaque, according to the nature of the work required. The base lines are measured by means of sets of

compensating bars and microscopes, on the principle of those designed by Colonel Colby for the Ordnance Survey of Great Britain. The other general operations of the Great Trigonometrical Survey comprise: topographical surveys of the Himalayas and of the province of Kattywar, geographical explorations of Trans-Himalayan regions, astronomical observations for determining latitudes of stations of the triangulation, levelling operations, geodetic and magnetic observations for determining, at certain stations of the Great Arc, the number of diurnal vibrations of two pendulums, the property of the Royal Society of London, and measuring the magnetic dip, declination, and total force at the same stations.

The head-quarters office at Dehra comprises two principal branches, viz., the computing office, with a *personnel* of an officer in charge, 3 European assistants, and 12 native computers employed in the examination, reduction, and publication of the trigonometrical and astronometrical observations. This branch of the office also undertakes monthly magnetic and daily meteorological observations at Dehra, and, during the recess, at Masoori, comparison of standard thermometers and barometers, and other scientific operations. The other branch consists of a drawing office, for the preparation and publication of the various charts and maps emanating from the trigonometrical operations and explorations in progress, under the direct control of the superintendent. The Dehra office also comprises a printing-office and a small photozincographic establishment for the reproduction of maps and charts by photozincography, or simple zincography. The photozincography process used is almost identical with that used at the Ordnance Survey Office at Southampton, and is found to work very successfully in the comparatively fine climate of Dehra. The charts of the trigonometrical operations are zincographed on a scale of 4 miles to the inch, and the geodetical co-ordinates for each station, with azimuths and linear distances, are entered upon them, so that each chart forms a brief but complete record of the survey results. Skeleton charts of levels on a scale of 2 miles to the inch are also prepared and photozincographed. These show the combined results of both trigonometrical and spirit levelling reduced to the common datum of the mean sea level of Kurachee harbor. The maps and plans prepared under the direction of the superintendent, Great Trigonometrical Survey, vary in scale. The greater number are photozincographed at his head-quarters, and a few are lithographed at the Surveyor-General's Office, Calcutta.

The ground-work or basis of the operations of the Topographical Survey is secondary and minor triangulation dependent on the Great Trigonometrical Survey operations, from which all the initial elements of latitude, longitude, elevation, distance, and azimuth are derived. The triangulation is carried on in a network covering the ground with points or stations at about 3 to 4 miles apart. The instruments employed for the secondary triangulation are vernier theodolites with 12 in. and 14 in. azimuthal circles; the horizontal observations are taken on 4 zeros repeated, and the vertical angles on 2 zeros. For the subsidiary, or minor network of triangles, theodolites with 7 in. and 8 in. azimuth circles are used, and the angular measurements are made with 2 zeros repeated. The detail work, or delineation of the configuration of the ground, is executed usually on the moderate scale of 1 in. to the mile; some topographical surveys in cultivated and valuable tracts are, however, on a scale of 2 in. to the mile, whilst a few others in very broken and wild ground are on the scale of $\frac{1}{2}$ in. to the mile. In addition to these surveys, the topographical branch undertakes the plans of all the important cities, forts, and strongholds in native states, which are mapped on scales varying from 6 in. to 16 in. to the mile.

The Revenue Survey of the Bengal Presidency is a scientific periphery admeasurement of the land by means of angular and linear measurements, performed with theodolites and steel chains. It is a definition and survey of village boundaries and estates, and may also be termed a large scale topographical survey, as it affords accurate topography of every district falling within the scope of its operations, and is admirably adapted to all open and champaign districts. The system followed by the Revenue Survey is that of traversing with the theodolite and steel chains, known as Gale's method of land surveying, modified to secure greater accuracy and efficient checks on both the

boundary and interior detail measurements. Large areas are first traversed with the better class of small theodolites, starting from an initial station, where the azimuth is observed, to obtain the true bearing of the stations in advance. These areas are called main circuits, and they are subsequently subdivided into minor or block circuits; these minor circuits being in their turn traversed and proved true on the basis of the main circuit containing them. The interior, or detail survey, which is filled in by plane table or compass and chain, rests upon these small village polygons, plots of which are furnished to the native plane tablers. The field mapping is all executed on a scale of 4 in. to the mile.

In the Presidencies of Madras and Bombay minute cadastral measurements of fields are in progress under European officers; these surveys are essential for settlement and revenue purposes, and have no connection with the Indian Survey Department, nor are they under the direction of the Surveyor-General of India.

COMPARATIVE EFFECTS OF GUNPOWDER AND GUN-COTTON.

From "The Mechanics' Magazine."

A number of experiments have been recently carried out by the officers of the Royal Engineers at Chatham to test the comparative effects of gunpowder and gun-cotton in various operations. The experiments were all under the direction of Colonel W. O. Lennox, C. B., V. C., Instructor in Field Fortifications at the School of Military Engineering, assisted by a number of other officers. The experiments were attended by a large muster of officers of the garrison, besides those of the Engineer Corps, and also by Major-General J. L. Brownrigg, C.B., the commandant of the garrison; Colonel Wray, Colonel Graham, C.B., V.C.; Colonel Fiser, Colonel Lovell, commanding Royal Engineers; Colonel the Hon. H. F. Keane, Deputy-Adjutant-General Royal Engineers; Colonel Clarke, etc. Mr. F. A. Abel, chymist to the War Department, was also present and assisted in some of the experiments with gun-cotton. The experiments commenced with explosions of gunpowder and gun-cotton directed against a double stockade of balks of timber 14 in. square, 3 ft. 6 in. apart and sunk 3 ft. in the earth, each line braced together by strong cross pieces. A charge of 200 lbs. of gunpowder, in bags merely laid at the foot of the stockade, untamped, was first exploded. It forced a large gap in the front stockade, but, though partially shattered, the second row of timber would have presented a formidable obstacle to an attacking party if defended by a few resolute men. Portions of the timber were hurled through the air to some distance. A charge of 80 lbs. of gun-cotton was next laid in bags at the foot of the stockade, some distance from the former explosion. This also was untamped. It was fired by a detonating fuse. There was a terrific explosion, and an almost perfectly clear breach was made through both rows of timber, practicable for an attacking party to get through. The effect was very much superior to that of the 200 lbs. of gunpowder. Immense pieces of timber were hurled through the air to a great distance, mostly in the rear of the stockade. Not so wide an extent of timber appeared to be shaken as by the first explosion, but the work was more completely done; the results, indeed, were extraordinary. Experiments were also made by exploding discs of gun-cotton against single balks of timber, to show what effect would be produced if timber bridges had to be destroyed. Four balks of timber, about 16 in. square, were sunk in the ground some feet apart, in a square, and braced together by thick pieces of plank. A "necklace" of small discs of gun-cotton was formed (about 68 in number); this was doubled and placed half round one of the timbers. The explosion of this string of discs tore away the wood for some depth, 4 in. or more on one side of the balk, but did not break it, though the massive timber was much rent. Three or four larger discs were then exploded on one side of the timber, and tore out a large portion of the wood. A single "necklace" of small discs, 65 in number, and weighing 2½ lbs., was then placed round another balk, quite encircling it. When exploded this tore out the wood all

round to some depth. Then 12 of the larger discs, weighing 4 lbs. 2 oz., were hung on nails on three sides of the timber, and exploded. The explosion was very powerful, and the large balk was cut in two—snapped off where the gun-cotton had been attached, but falling on the side where there had been no discs and partially splitting on that side. The spectators cheered at this decisive proof of the value of gun-cotton for this special purpose. All these experiments appeared to be very satisfactory. At that part of the lines in front of St. Mary's Barracks, a number of mines and galleries had been excavated and charged with gunpowder or gun-cotton. One mine had a charge of 500 lbs. of gunpowder; a second similar mine was charged with 200 lbs. of gun-cotton. Two smaller mines were charged respectively with 21.6 lbs. of gunpowder and 8.6 lbs. of gun-cotton. These mines were successively exploded by means of an electric current. In the larger mines the powder appeared to be the most effective agent. In the explosion of the 200 lbs. charge of gun-cotton, a peculiar effect was produced; first, there was the eruption of brown clay and smoke, and then a large flame, produced by the ignition of the gaseous products of the explosion. The officers then proceeded to the old Engineer Depot, near St. Mary's Convict Prison, and walls which are to be removed were experimented upon; they are 18 in. thick; charges of gun-cotton ranging from 2 lbs. to 3½ lbs. were exploded against these walls, with satisfactory results, making breaches in them. The officers then returned to the scene of the mines, where two long galleries had been prepared, one charged with 240 lbs. of gunpowder, the other with 96 lbs. of gun-cotton. These charges were exploded. The object was to ascertain if it is practicable to form trenches in this manner, instead of throwing them up while exposed to the enemy. It was thought by some officers that the explosions would throw the earth up on either side in such a manner as to form a trench; but the result was not so—the earth was thrown up in a mass, and no trench was formed in which men could get under cover at once.

The experiments created the greatest interest among those who witnessed them, and were highly satisfactory.

OCCLUSION OF GASES BY ELECTRO-DEPOSITED IRON.

From "The Engineer."

M. Lenz has published at St. Petersburg a very interesting paper on an investigation which he made of the properties of iron thrown down in the metallic form from its solutions by a battery, and the chief results of his inquiry are given below. Iron deposited by a galvanic current is noted for its hardness, color, texture, and capacity for occluding gases. The specimens that M. Lenz employed in his researches were obtained by Klein's method from a solution of protosulphate of iron with which sulphate of magnesia had been mixed, by aid of a weak current, the solution being kept neutral by carbonate of magnesia. Under these conditions the deposit has a beautifully fine granulated structure, in which the microscope failed to detect any crystalline characters. The color is a soft, brilliant gray, the hardness 5.5, which means that the iron scratches apatite and is scratched by felspar. During deposition, even when a *thick* copper plate (a Daguerreotype plate) was used, this plate begins to bend as soon as the iron has attained a certain thickness, the concave side being turned towards the other electrode. If the copper plate be very thick, or the iron quite thin, no contortion, it is true, is observed, but that there is an inclination to do so will be remarked on dissolving off the iron from the copper. The plate in bending takes the form of the face of a cylinder whose axis is horizontal. If the iron be slowly deposited on a polished face it presents, when thin, an unbroken surface with a velvet-like aspect; as it grows thicker it becomes vesicular, and little depressions of an oval form are observed.

The iron thus prepared loses many of its characteristics by being heated over a charcoal fire. Its hardness sinks to 4.5, and though when newly deposited it was exceedingly brittle, it now possesses the

opposite character in a very marked degree. Thin films recently deposited can be easily crumbled between the fingers; after they have been heated, however, it is quite impossible to do this. They may be torn or cut with scissors, as we can tin-foil, but broken they cannot be, though bent backwards and forwards repeatedly along the same line. The plate of iron has acquired greater powers of durability than a sheet of paper possesses when submitted to similar manipulation. When heated in vacuo, or in an atmosphere devoid of oxygen, the iron becomes as white as the platinum used for chemical apparatus. Iron ignited in this way rusts quickly, both in air and in water whose air has been expelled by boiling. In the latter case the water becomes green in a few minutes, and after some hours its surface is covered with a layer of rust; if, on the other hand, deposited iron be taken which has not been heated, but few spots of rust make their appearance under the like circumstances of exposure. As the metal rusts, gas is absorbed, and it is probable that a decomposition of water takes place.

Again, as regards their electrical characters, the ignited and non-ignited iron comport themselves very differently. A galvanic element was formed with a solution of caustic potash, and two plates of iron, one of each kind; or each of these was in turn replaced sometimes by a plate of zinc and sometimes by one of copper. The strength of the current was determined galvanometrically, and as the plates were in all cases placed at one and the same distance apart, the result of the galvanometric measurements may be taken as a measure of the electromotive force. Below are the results:

	Deflection of needle.
Ignited iron and non-ignited iron	− 6
Copper and non-ignited iron	− 9
Copper and ignited iron	+ 11
Copper and zinc	+114
Ignited iron and zinc	+114
Non-ignited iron and zinc	+ 91

The volume of gas removable from the iron by the application of heat and the aid of the air-pump varied according to the thickness of the plate between pretty wide limits, one volume of iron taking up from 20 to 97 volumes of gas. It consisted of hydrogen, nitrogen, carbonic oxide, carbonic acid, and aqueous vapor. To determine their volume the iron was cut into small strips, introduced into a porcelain tube, which was closed at one end, and communicated at the other with a Sprengel's aspirator. Exhaustion at ordinary temperature drew out no gas whatever; the tube was finally brought to a white heat in a charcoal furnace, and the liberated gases examined by the method which Bunsen has given in his "Gasometry." The results of the analysis of the gases from four specimens of iron are given below. No. 1: Iron precipitated on a brightly polished Daguerreotype plate, of extremely fine grain, not vesicular. Thickness of metal, 0.08 mm. No. 2: Iron plate prepared by Klein by the method in use at the Russian State Paper Office. Surface finely granular, and distinctly vesicular. Thickness, 0.125 mm. No. 3: A similarly prepared plate, of equally fine grain. Thickness, 0.14 mm. No. 4: Plate deposited by extremely weak current. Thickness, 0.27 mm.

	1.		2.		3.		4.	
	Volume of gas, that of iron being 1.	Percentage composition.	Volume of gas, that of iron being 1.	Percentage composition.	Volume of gas, that of iron being 1.	Percentage composition.	Volume of gas, that of iron being 1.	Percentage composition.
Hydrogen,	52.2	53.4	15.8	68.7	12.8	60.4	12.0	58.8
Nitrogen,	15.2	15.5	0.8	3.5	1.2	5.6	1.2	5.8
Carbonic oxide,	14.7	15.1	5.5	23.9	5.7	26.7	3.6	17.4
Carbonic acid,	12.4	12.7	0.4	1.7	0.9	4.3	2.8	13.6
Aqueous vapor,	3.2	3.3	0.5	2.2	0.6	3.0	1.0	4.9
Total,	97.7	100.0	23.0	100.0	21.2	100.0	20.6	100.0

The carbonic acid and carbonic oxide are evidently derived from the solution out of which the metal is deposited, for to neutralize the excess of acid carbonate of magnesia was added from time to time; and the nitrogen must have been obtained from the same source. The percentage of these three constituents varies in a remarkable degree, and the same is true of the absolute amount of gas occluded. It is evident that the thickness of the deposit exerts an influence here, for the thinnest film of metal (0.08 mm.) absorbed 97.7 volumes of gas, and with an increasing thickness of the plate the relative amount of gas is seen to diminish. It follows from this that the greatest amount of gas is taken up at the commencement of the operation. To determine this more accurately some special experiments were made. Two silvered copper plates had lines drawn lengthwise on them, dividing on one plate the surface into three equal parts, and on another its surface into four equal parts. They were then immersed in the bath and covered with a thin film of metal. One division after another was now coated with varnish, and the plate again immersed in the iron solution, so that the last film became the thickest. The varnish having been removed with alcohol, the plates were broken into three and four parts respectively along the lines, and the gas occluded by each portion determined. Finally, from the results of these analyses, it was an easy matter to calculate how much gas was absorbed when a plate increased 0.01 mm. in thickness. The numbers are as follows:

	Exp. 1.	Exp. 2.
0.01 mm. thickness of the first layer absorbed	18 c.c.	17 c.c.
0.01 mm. thickness of the second layer absorbed	4 "	9 "
0.01 mm. thickness of the third layer absorbed	3 "	6 "
0.01 mm. thickness of the fourth layer absorbed	—	4 "

To the more abundant occlusion of gas by the first layer of iron must be ascribed the contortion attending deposition, as well as the circumstances that, after a certain thickness of metal has been reached, the formation of vesicular metal seems unavoidable. The rusted iron was also subjected to a searching inquiry, and it was shown that during oxidation water was decomposed and hydrogen absorbed. A fragment of the iron used in Experiment 2 was freed by powerful ignition from all gas, and immersed four days in water. The rust having been removed as completely as possible, it was heated to a bright red heat in the tube of the Sprengel's aspirator. The gases extracted were 2.54 volumes of hydrogen, 0.06 volume nitrogen, 0.02 volume carbonic oxide, 0.053 volume carbonic acid, and 0.067 volume aqueous vapor, or 3.82 volumes in all. The comparatively large amount of watery vapor was supposed to be due to the rust that could not be removed completely, and whose oxygen at the high temperature of the experiment would convert some of the liberated hydrogen into water. Assuming this to have been the case, the hydrogen would amount to 3.21 volumes, or 84.0 per cent. of the gases liberated. Iron deposited by a battery, then, possesses the property of decomposing water, and absorbing hydrogen thus set free.

M. Lenz examined the comportant of copper when deposited by a battery. He found the gases occluded by this metal to be 3.4 volumes of hydrogen, 0.37 volume carbonic oxide, 0.49 volume carbonic acid, and 0.14 volume watery vapor, or 4.4 volumes of gases in all; or in other words, he has shown that copper, when deposited, absorbs gases, the greater part of which is hydrogen.

THE railway bridge at Strasbourg has been rendered impassable by removing a sort of drawbridge on the French side. It is stated that on the Baden side this arrangement could not be made, and so their share of the bridge is already mined, to be blown up, if necessary, at a moment's notice.

PARLIAMENTARY powers will, it is said, be sought to authorize the formation of an embankment along the foreshore at Cremorne, with a view to the continuation of the Thames Embankment from its authorized termination at Chelsea to the northern end of the Battersea Bridge.

MEASURES have at length been taken for the preservation of fish in the canals of India by limiting the meshes of the nets.

OUR SYSTEM OF MILITARY BRIDGES.

From "The Engineering and Mining Journal."

The safe and rapid passage of rivers in the field is one of the most important and delicate of military operations. Instances might easily be cited, not only in our late war, but in many others, where, through the absence of a proper pontoon train, the most brilliant opportunities have been lost.

Our own system of military bridges is not a superficial and sudden creation. It is the result of careful study, patient and long-continued experiments, and great experience in the field. In December, 1868, the Chief of Engineers of the United States Army, organized a Board for the purpose of improving and revising the bridge-system. This Board was composed of officers of long and distinguished connection with the Engineer service; and the result of their labors is now issued, under authority of the Secretary of War, as the improved system of drill and instruction for the line of the United States Engineers. The book is accompanied by an atlas, containing a large number of working drawings, sufficiently in detail to serve for the construction of the complete train.

In order to give an idea of the system adopted, and the reason which induced the Board to recommend it, we select from the report a few facts concerning the bridge-train and its history. Previous to the Mexican War no attempt was made to organize a bridge-equipage in our service. During this war two complete trains of india-rubber pontoons were constructed and sent into the field. At its close, those trains were sent to West Point, where they were used for the instruction of cadets and engineer troops. A full description of this equipage is given in the "Professional Papers, Corps of Engineers, No. 4."

It soon became evident that india-rubber is not at all adapted to the construction of pontoons.

First.—From the perishable nature of the material. The cylinders are formed of alternate layers of canvas and india-rubber. The sulphur used in the process of vulcanization generates sulphuric acid, which soon destroys the fabric of the cloth.

Second.—The extreme elasticity of this species of support gives to the bridge a rocking and oscillating motion, so violent as to render it unsafe for the passage of animals.

Third.—The most serious objection, however, is that a puncture, either above or below the water-line, is equally fatal to the cylinder. Hence, a single sharp-shooter, from a rifle-pit on the enemy's side of the stream, can destroy these pontoons as fast as they are launched.

In the autumn of 1858, the india-rubber pontoons having become entirely unserviceable, experiments were made to determine the composition of a bridge-equipage that should be adapted to our service. In conducting these experiments, the following fundamental rules were kept constantly in view.

First.—The mobility of the train must be such as to enable it to keep pace with all the movements of the column to which it is attached.

Second.—The train should furnish the means of ferrying troops promptly and safely, as in the case of disembarkation, and the passage of a river by force.

Third.—It should furnish the means of constructing a bridge capable of passing an army with all its trains over the largest and most rapid rivers, with safety and without delay.

Now, under the most favorable circumstances, it is very difficult to reconcile the first and third of these rules, when but one species of pontoon is employed. In this country it is impossible. The immense trains with which our armies are unavoidably encumbered, the long marches to be made, and the numerous wide and rapid rivers to be crossed, demand an equipage of the most substantial character. On the other hand, the extended expeditions of light columns, which necessarily attend our military operations, require a train light enough to keep pace with the most rapid cavalry movements.

Hence we require both a reserve and an advance-guard train.

The experiments above named included the trial of samples of the bridge equipages used by those European armies most experienced in the art of military bridge

building. Pontoons were constructed after the models of the French bateau, the Austrian sectional pontoon, and the Russian canvas-boat. Corrugated-iron boats were procured corresponding as nearly in form and dimensions to the French and Austrian boats as the nature of the material would permit. A number of Birago trestles were also constructed. All of the above material, with the exception of the iron boats, was prepared by the enlisted men of Company A, Engineers.

The bridges formed of this varied material were exposed as much as possible to the action of heavy loads, storms, the tide and floating ice. The material was also packed on carriages of various patterns in order to ascertain the best form, both of bridge material and carriage, for transportation.

The selection of the French, Russian and Austrian trains for these experiments, was made after a careful study of the various equipages used at present by the armies of Europe. These three nations alone appeared to have definitely settled on their systems, and this after much experience and thorough research.

The Prussians and Spaniards were seeking for substitutes for their bridges, which had proved unsatisfactory. The Sardinians had adopted a plan inferior to that of the Austrians, though similar in some respects. The English tin pontoon had too many of the defects of the india-rubber to answer our purposes.

After experimenting for two years with the above-mentioned material, the following conclusions were reached: The French pontoon is superior to the Austrian in simplicity and stiffness; as a ferry-boat, it will transport more troops, and is more easily managed; in the bridge, its superiority is marked. With the French equipage, the corresponding balks of the adjacent bays lap each other about six feet, and are finally lashed together and to both gunwales of the pontoon, which greatly increases the strength and stiffness of the roadway; while with the Austrian, the balks must meet on a sill directly over the axis of the boat. The bays thus hinging on this side, full play is allowed to the horizontal and vertical oscillation to which floating bridges are subject.

As to land transportation, the French train requires fewer carriages to transport the same length of bridge than the Austrian, since for each section of the latter pontoon a separate vehicle is necessary. The length of the two carriages does not differ materially, this being determined by the length of the balks.

These considerations led to the adoption of the French pontoon.

The next question was, what material should be employed in its construction? Life-boats having been successfully manufactured in this country out of corrugated iron, it was presumed that this material could be used with equal advantage in the present case. The first boat, made of the same thickness of metal as the largest class life-boat, proved to be deficient in stiffness when placed in the bridge. The corrugations, running from bow to stern, diminished the power of the sides to resist the vertical strain caused by the weight of the roadway on the gunwales. To remedy this defect it was proposed to line the boat amidships with iron corrugated vertically, or to introduce strong iron ribs.

These expedients, though they would have increased the weight beyond that of the wooden pontoon, might have been successful; but they were not attempted, as the boat failed in other respects. In fact, it would not bear transportation; as, in travelling over a rough road, the joints open, either the rivets or the sheet iron giving way. When in the bridge, if the boat grounds on an uneven or rocky bottom, a hole is frequently punched through it, and such injuries cannot be repaired in the field. The wooden pontoon is not only much less liable to such accidents, but can be readily repaired when they do occur.

Previous to the battle of Gettysburg, a pontoon bridge over the Potomac at Harper's Ferry was destroyed, the pontoons being scuttled and set adrift above the rapids. About three weeks after, the water having fallen, the boats were recovered, repaired with pieces of hard-bread boxes obtained from the commissary, and used in constructing a bridge at Berlin, over which the entire army passed into Virginia.

With regard to the canvas boat, it soon became apparent that it is precisely what we require for our advance-guard train. It is light, simple, strong, easily repaired, and when packed can be safely transported with the superstructure of the

bridge as rapidly as any column of troops can move. A strong argument in favor of its adoption was that it had been used successfully by the Russians for more than a hundred years, under every variety of circumstances likely to occur in this country.

The selection of the carriage for transporting the bridge material was next taken up. The French pontoon wagon is not adapted to our rough roads. The wheels are too small, and cannot be increased in diameter without raising the load too high above the ground.

A carriage was finally devised on the principle of the four-horse truck used in this city. By means of the horizontal fifth wheel over the front axle, and of an inclined wagon-bed, forward wheels of the requisite size were enabled to reverse completely under the load, thus allowing the carriage to turn in a short space. This construction is absolutely necessary when wagons so long-geared travel over a crooked road.

For the chess wagons and canvas train, a similar wagon would, without doubt, have answered the purpose perfectly, so far as transportation is concerned ; but the ordinary baggage wagon of the Quartermaster's department, with some modifications, was used on account of the facility with which it could be obtained, and the readiness with which spare parts could be procured for repairs in the field.

The Birago trestle, which had been recently adopted by most of the European nations, was also thoroughly tested ; and the result proving favorable, it was proposed to employ it in connection with the pontoons of both trains.

From the information gained by these experiments, there resulted the system of bridge equipage adopted at the commencement of the late war. During the winter of 1861–'62, five trains were constructed, each composed of thirty-four pontoons and 8 trestles, the pontoons being nearly of the same form and dimensions as the French bateau. The frame was somewhat different, the ribs being entire and strongly ironed, and the ironing stronger throughout. The stern was provided with a locker. There were also other alterations in the details of construction. The balks were stronger ; and the Birago trestle was modified by substituting built beams, instead of solid timber, for the trestle-caps and balks.

At the same time several canvas trains were organized. In constructing the pontoon-frame, the dimensions and form of the Russian boat were exactly retained. The scantling for the frame was considerably lighter, but, being strongly braced and ironed, the strength was about the same. One train was composed of canvas boats and trestles ; being, in truth, a trestle train, with auxiliary pontoons to be used only where the depth of water, or muddy bottom, prevented the use of trestles.

In the month of February, 1862, a pontoon bridge, composed of about 60 boats of the reserve train, was thrown across the Potomac at Harper's Ferry. The river was then a perfect torrent, the water being 15 ft. above the summer level, and filled with drift-wood and floating ice. The greatest difficulty was experienced in pulling the pontoons into position, and it was necessary to make use of ship anchors and chain cables to hold them in place. Notwithstanding these unfavorable circumstances, the bridge was completed in about 8 hours, and the corps commanded by General Banks, with all its trains and artillery, passed over it without accident or delay.

Several of these trains accompanied the army in the Peninsular campaign. The pontoons were used in discharging quarter-master and commissary stores at Ship Point, in disembarking General Franklin's command at West Point, and in constructing bridges over Hampton Creek, the streams in front of Yorktown, and the Upper Chickahominy. Finally a bridge was built over the Lower Chickahominy, about 2,000 ft. long, over which nearly the whole army of the Potomac, with its immense trains, artillery and cavalry, passed with promptness and safety.

After the army had passed, the bridge was dismantled and the balks, chess, etc., passed into the pontoons, which were formed into rafts, and towed by steamers to Washington. The bridge-trains were next transported to Harper's Ferry, where a bridge was constructed a second time, but under entirely different circumstances from that built during the previous winter. The water was now not deep enough; and as it continued to subside shortly

after the bridge was laid, many of the pontoons grounded on a very uneven and rocky bottom. Some of them were completely out of water, yet the heavy trains continued to move over the bridge without seriously injuring them; and when the water rose, most of them floated as well as ever..

Discovering in this way that the boats were much stronger than had been supposed, the engineers were enabled to improve the method of bridging tidal streams.

It had formerly been considered necessary to build out to low-water mark with trestles, so that the pontoon should always be afloat. The bridge is now commenced at high-water mark, building with pontoons alone. As the water subsides, the pontoons nearest shore ground successively, forming a gentle ramp from the abutment to the floating portion of the bridge, instead of making the descent in 20 ft. as formerly. This method, of course, applies only to wooden pontoons, and to cases where the bottom is favorable.

During the Fredericksburg campaign, it became necessary to force the passage of the Rappahannock. The enemy having entrenched themselves on the bank, prevented for some time the construction of the bridge; until, at length, troops were embarked in the pontoons and ferried across, where they stormed the rifle-pits, and held them until the bridge was completed.

During the year 1863, the pontoon-trains accompanied the army in all its marches backward and forward through Virginia, frequently bridging the Potomac, Rapidan and Rappahannock. In the latter stream, the bridges remained in position all winter, and, notwithstanding the frequent floods and the quantity of ice formed, but few interruptions occurred upon these thoroughfares.

During the campaign of 1864, trains composed of 14 pontoons and 2 trestles accompanied each of the 3 army corps of the army of the Potomac. These trains attended their corps in the long march from Culpepper to the James river; and although the roads were frequently very bad, in no instance did they delay the march of the troops, or arrive late when a bridge was to be laid.

The headquarters' train was followed by a canvas train, which, when a crossing was to be made by surprise, was sent forward with the cavalry, who covered the construction of the bridge and held the position until the main body arrived.

On reaching the James river, a bridge was laid opposite Charles City Court House, about 2,000 ft. in length. The water was so deep and rapid that the pontoons could not be held by their own anchors, and it was found necessary to attach their cables to schooners anchored above and below the bridge.

Thus the wooden pontoon-trains, through 4 years of war, during which the bridges constructed were without parallel in number and magnitude, amply fulfilled all the requisites of a good bridge-equipage. The frequent crossing of the Chickahominy, Potomac and James rivers, proved that, even under the most unfavorable circumstances, it could furnish a bridge capable of passing a large army, with its heaviest trains, over wide and rapid streams, with safety and dispatch. Its capabilities in ferrying troops were shown at Ship Point, West Point and Fredericksburg; and of the mobility of the equipage there was abundant proof in the long marches during the last two years of the war.

The canvas equipage, also, was perfectly successful as an advance-guard train. In the cavalry raids it was always able to keep pace with the columns; and, although they frequently marched hundreds of miles, it was invariably ready to furnish a prompt and secure means of crossing all the streams on their route. It also often furnished bridges for the heavy trains of the army over streams of moderate width and rapidity.

The only part of the bridge equipage which did not realize the expectations of the engineers, was the Birago trestle. As already remarked, a train was organized early in the war on the Austrian principle, in which the trestle is the main dependence, the pontoon being merely auxiliary. It was supposed that many streams would be encountered which could be bridged best with trestles alone, but none such were met with. In fact, when a stream is more than 2 ft. deep, a pontoon-bridge may be laid; when less than that depth, if the bottom is hard, it may be forded, and no bridge is required. Should the bottom be soft, the trestle-legs will usually settle, so as to render the bridge

unsafe. As it was not deemed advisable to transport with the army a train which could only be used in exceptional cases, this description of equipage was abandoned. The trestle was, however, very useful as an auxiliary, especially with the canvas train; for as these boats, when in the bridge, should never be allowed to touch the bottom, it is frequently necessary to build out several buoys from the shore before sufficient depth of water can be obtained to float the pontoon; and for this purpose nothing could be better than the Birago trestle, which is also equally useful for a similar purpose with the reserve train, where the river bottom is rough near the shore.

The canvas train was extensively used by the Western army, and with such success that it was proposed to employ it exclusively. Experience, however, in the East has clearly proved that this train cannot fulfil all that is required of the bridge equipage of a large army. The bridges of the Potomac and James rivers could not have been built with canvas boats, which will not resist ice and drift-wood; neither are they suited to the disembarkation of troops or the passage of a river by force.

Experience would, therefore, lead us to concur with General Barnard, in his remarks on this subject, namely:—

"The numerous proposers of 'flying' bridges forget that, if a military bridge is intended to be *carried with* an army, it is also intended to *carry* an army, its columns of men, its cavalry, its countless heavy wagons, and its ponderous artillery. It must carry all these, and it must do it with certainty and safety even though a demoralized corps should rush upon it in throngs.

"No make-shift expedients, no 'ingenious' invention not tested by severe experiments, no light affair, of which the chief merit alleged is that it is light, will be likely to do what is required, and what the French pontoon has so often done."

The United States bridge equipage is, therefore, composed of two distinct trains—the reserve and the advance-guard trains. The former are intended to accompany large bodies of troops in the field, and are provided with the materials for the construction of bridges of sufficient capacity to pass large armies, with their heaviest trains, over rivers of any size and capacity. For these, the French pontoon is adapted.

The advance-guard train is intended for the use of light troops, such as advance guards, cavalry expeditions, etc. It is organized both as regards material and carriages, with a view to rapidity of movement. At the same time, it is capable of furnishing a bridge which will fulfil all the requirements of troops engaged in such service. For this train the canvas pontoon is adapted.

The Board have made many improvements in the details of the trains, such as the wagons, tools, materials, etc., submitting every change to the test of actual practice at the Engineer School at Willet's Point. The system of instruction has been also made much more complete than it was heretofore, and it now comprehends all that is necessary for the service of the train, from the elementary drill of the individual pontonier up to the construction of the most elaborate bridge.

The system of instruction is not wholly confined to the construction and management of floating bridges. There is an admirable chapter on the passage of rivers, which contains many valuable expedients for performing this operation, when circumstances render the use of the pontoon-bridge unnecessary or impracticable. There is also a section treating of expedients with insufficient trains; and, still more important, a complete chapter on the construction of bridges without the bridge equipage.

A ready and intelligent use of expedients is, perhaps, the most valuable quality of mind that a military engineer can possess, and we may justly claim this quality for our people in a most remarkable degree. The record of our military engineers during the war is proof that they are not, like too many military men, bound down by routine, and helpless beyond it, and the presence of such suggestions and such instructions in a drill-book of the Regular army, is still further evidence to this fact.

According to Dr. Cayley, the gold-fields of Khotan are practically inexhaustible, and gold is obtained from them without any great labor or difficulty.

THE DECORATIVE ART OF JAPAN.

From "The Builder."

The glances which we have been enabled to take, from time to time, at the state of art-education in this country, as well as on the continent of Europe, have led to the conviction that, however we may regret the want of due encouragement of the highest forms of art amongst ourselves, we are actually providing a school of decorative and industrial art which has produced much, and which promises more. Leaving aside, therefore, for the moment, the consideration of the great master-principle of the unity of art, and looking at the practical question, how best to stimulate the exertions, and to improve the results, of our actual schools, within the limits to which they are at present restricted, it becomes a matter highly important to the national welfare to inquire in what localities, and to what masters, we are to look for instructive and improving examples of decorative art. We do not doubt that those whose opportunities of study have been such as to acquaint them with the subject, will at once anticipate that we are about to speak of Japan.

It is, indeed, to Greece, in the age of Phidias, that we invariably turn for the noblest examples of the highest forms of art. That this excellence was not confined to plastic art alone, we have the unique, but unquestionable, witness of the "Muse of Cortona," a Greek painting, discovered, comparatively lately, in Italy. In the decoration of the vases of Greece and of Magna Grecia, the historic development of which we may, to a very great extent, trace in the noble collection exhibited in the British Museum, we see rather the exuberance of the art-instinct, as displayed in the work of the potter, than the results of the demand of luxurious taste for sensuous ornamentation. Among the few ancient bronzes in the Italian museums are to be found the *chefs d'œuvre* of all human art. Coins of rare beauty attest the unrivalled excellence of the Greek die-sinkers: and *intaglio*, and even *cameo* gems, such, for example, as those signed by Pyrgoteles, are the masterpieces of an all but extinct mystery of the cunning of relief.

The art of Greece is of that nature of which it is said, with truth, *nascitur, non fit*. While the artist who attempts that which is most noble will ever seek inspiration and instruction from the cradle of genius, any endeavor to reproduce classic forms in their purity, in the present century, is likely to result, as it generally has resulted, in failure. We may spell a certain number of words with a K instead of with a C, without imbibing, by that or by any similar methods, any portion of classic inspiration. The style of the school of David, essentially artificial as it was, is fading from the French academies; in spite of the political reasons which dispose so large a portion of an impulsive nation, toward an imitation of all that was republican in antiquity. The effect of an exclusive study of classic forms—of the second-hand study of nature—in starving the mind, and in impoverishing the hand, is illustrated in a remarkable manner by the works of Flaxman. No artist in modern times had a purer taste, as far as taste could be formed by the love and study of the antique. His power of bold, striking, truthful drawing is evinced by his Italian note-book, full of masterly and admirable sketches of Italian art. Unfortunately, it was the dry bones of the past alone, that this artist found in Italy. He wandered through districts in which, even at this moment, female beauty may be almost called divine, without sketching, so far as his book is evidence, a single exalting model of nymph, or goddess, or virgin. Every scrap of Roman sculpture —poor, ill-drawn, and harsh as these relics often are—had a greater charm for his eye than the lithe forms of the women of Sessa, or the almond eyes of the girls of Lecce or of Brindisi. The natural, necessary result of this indifference to the mundane source of the Greek ideal, is to be seen in most of Flaxman's designs. Of the large number of sketches recently displayed in the Loan Collection at the South Kensington Museum, there was hardly one which an artist acquainted with living Italy (if she can be said to live), would care to copy, or even to possess, except as an autograph.

Admitting, as we must do, that the tone and temper of the day are not such as to allow us to expect the very proximate

introduction, into this country, of the class of art-education which is attempted by more than one Continental Government, it is evident that, in order to make the best of the education actually given, we must not hold too closely to Grecian models. As a mode of instructing both eye and hand in precision of form, and, to a certain extent, as a mode of forming and purifying the taste, the wiser method of copying, alternately, from the antique and from life, which has been introduced into our schools of art, is admirable. In this particular (and probably in this alone) Continental schools may take a lesson from our own; but so long as our national education is directed to the formation, rather of the art-workman than of the artist proper, we ought to look eastward of Greece for the source of his inspiration. The tendency of the human mind, especially during the time when knowledge is but in the course of acquisition, to mistake *a* principle for *the* principle, is normal and constant; this evidence of partial and imperfect education is constantly out-cropping in art. It is the origin of most so-called "schools." It erects into distinct academies those minor divisions which ought to be only "forms" in one great, harmonious university of art. It speaks of the conventional, the realistic, and the ideal, as if any true art could exist which did not combine the three. But it is not falling into this vulgar error to insist that the conventional element must preside over the department of decorative art. That point admitted, it follows that examples, invaluable for the use of our industrial schools, may be furnished by the artists of Persia, of China, and of Japan.

It is in the art-works of these countries that we find at once the most perfect treatment of color, as to harmonious blending, and the production of the effect of richness without gaudy vulgarity; and the most adroit management of geometric or arbitrary form in contrast to the flow and freedom of natural outline.

Japan may be regarded as the locality in which the most valuable discoveries in living art are now to be sought. Its civilization, as peculiar as that of China itself, differs from that of the flowery land, not only in its artistic, but in its historic, characteristics. The most valuable productions of the special craft which takes its name from China, date from the age of the Crusades. The most rare and precious of the various species of Chinese porcelain, fragments of which are now treasured and worn as gems, the azure crackle, was fabricated under a dynasty which ascended the throne more than a century before the Norman Conquest. The most delicate egg-shell china, thin as bamboo paper, was produced early in the 16th century. The rage for cheap production, extending from our shores to the antipodes, has had the same fatal effect on the porcelain of China, that it has had on the iron of England. Modern productions, apparently of "hard paste," are made to sell, and not to endure; and a collection of valuable porcelain is now as rarely to be met with in China as a chest of good tea—of which herb all but the cheaper qualities have fallen into absolute neglect in those districts which supply the English market.

But in Japan, as far as our limited acquaintance with that unique country extends, no signs are to be traced of decadence in art. Europe is only beginning to awaken to the vigorous life and the remarkable originality of the Japanese artists. It is true that we have long been acquainted with specimens of their rare cunning. The name of Japan, most inappropriately bestowed on the grim black paint, or the shining, splotchy, brown varnish, with which we decorate those iron boxes which are the pride of the legal profession, has been long cited as descriptive of that peculiar lacquer, of which we know little, save of two inferior kinds, the black and the red. Of the ten distinct orders of this peculiar manufacture, ranging as they do, from the gold lacquer, bright in all colors from that of fire to that of the rose itself, through the hues of aventurine and of tortoise-shell, to that vermilion paste (formed of fibres of urticaceous plants, bamboo paper, calcined snail-shells, and oil of camelias), which can be carved and chased like wood, little more than the names are known. Few of us are aware that not only wood, but china and metal, are incrusted with the precious lacquer of the Japanese. Here and there an amateur has picked up one of those rare little cups, Chinese, it may be, or Japanese, in its porcelain lining, the outside of which has been covered by the patient toil of the latter race with a web of wicker, delicate as lace, and firm as if

it were a portion of the earthen fabric itself.

The descriptions of produce which are known to be wrought, with unrivalled excellence, in Japan, include so large a range in industrial art as to suggest how wide a field, and that by no means unoccupied, must lie between. In variety, and in excellence of adaptation for widely different purposes, there are no *papers* like those of Japan. No European silversmith, bronzist, or other worker in metal, can emulate, or can altogether comprehend, the wonderful chasing, inlaying, tinting, and inexplicable transforming of metallic substances, effected by the Japanese metal-workers. Japanese porcelain has a style of its own. Wicker-work and bamboo-work of all kinds are employed, from the walls and roofs of the houses to the outside of the tea-cups. Of lacquer we have spoken. No country of Europe possesses so many specimens of Japanese work as does Great Britain. Her Majesty the Queen has given and has lent, to the South Kensington Museum, valuable specimens of China and of other industrial productions, including most curious grotesque groups in ivory. Up to the close of 1867 the Museum had acquired 183 specimens of Japanese art, of which 40 were carvings in hard wood, ivory, or bone, 20 were specimens of arms and armor, 54 were objects of a textile fabric, and an equal number represented the porcelain of the country.

Japan was not represented at the Paris Exhibition in a manner worthy of her artistic eminence. A few articles of interest, representing the products of the forests of the country, filled a single case. They consisted of fibrous substances, such as palm-leaf sheaths, out of which fine sweeping-brooms are made; wooden tooth-brushes, charcoal of the tree fern, palm fans, neat wooden boxes, sandals, shields, baskets, and ornamental articles, made from rattan cane, large bamboo stems, and the bark of the *Broussonetia papyrifera* and other trees.

A good collection of samples of paper was also exhibited at Paris. The purposes to which this material is applied by the Japanese are almost inexhaustible. Seventy descriptions are known. They paper their houses, they paper their rooms, they paper themselves; they have paper tiles, paper greatcoats, and umbrellas of oiled paper; despatch-boxes, reticules, and tobacco-pouches of a paper imitating leather; paper-cloth, as strong as leather itself; card-board, ornamented with gold figures, costing 4 francs per sheet; gold-spangled and embossed complimentary paper, delicate writing-paper, gelatine paper, wrinkled paper, paper pocket-handkerchiefs, sold at the price of from 4 to 14 centimes per score. It is only necessary for the attention of the Japanese artists to be turned to the subject, for us to be put in possession of lace-paper, suited for ladies' dress, which should unite the richness and delicacy of the finest *point d' Alençon* with an unsullied purity special to itself—the fire being the washerwoman—at an absolutely ridiculous price.

Japanese writing-pencils and cakes of various colored inks are also known in Europe. A case of toys was sent by the Japanese Government to the Paris Exhibition, containing rattles, dolls with movable eyes, dolls of white earthenware with grotesque faces, cups and balls, little boxes of kitchen articles, and similar objects. It was remarked, however, by the English reporter, that, owing to the contents of the case being sold, the guardian obstinately refused to give any information about them.

The peculiar silks with which Japan has lately supplied the European market, are pretty widely known. It is not, however, generally understood that the peculiar hardness and sharpness of these fabrics is due, in some unexplained manner, to the influence of the soil or climate of the island. For when what is called Japanese "seed"—that is to say, the eggs of the silk-moth—is imported into Italy, the descendants of the Oriental insects appear to become *civilized* by the inexplicable charm of the country (or the new food), and spin, after one or two descents, a finer and softer silk.

Of the works of the painters in Japan, we have but few specimens; but the originality of the canons of art which they follow is no less striking than is the case in other departments. The absence of defined outline is a marked peculiarity. Queer blotches, violent contrasts of color, purposed defiance of what we call symmetry (that is to say, making one side a reflection of the other), distinguish the toil of the Japanese painter, on wood, paper, or porcelain. Yet no one of these

apparently accidental defects can be obliterated without damage to the "barbaric" composition; and the student is forced to admit that there are laws of harmony and of proportion, whether of color or of form, too subtle for his grasp, but of which the Oriental craftsman evinces a perfect and an instinctive mastery.

The wonderful tiger now to be seen at the South Kensington Museum, may be cited as a characteristic specimen of the art of the Japanese painter. It has been previously described in our pages, but is now referred to as an instance of the mode in which nature can be simulated with an art almost equal to her own. Viewed at a distance, innumerable faults may be detected in the drawing, not only of the background, but of the animal. But when viewed closely, even through a magnifying glass, it is difficult to persuade the senses that one is not looking at actual fur.

In treatment of color, an instinct of harmony seems to pervade the Oriental schools, distinct as they are in minor characteristics, which exceeds the utmost skill of the educated European workman. The Indian artists inherit as their birthright, says an English artist and art-writer, a wondrous sense of harmony in tint and dye. In their work we see how gold and color can be brought together; how, through the most marvellous subtlety of color and tint, the greatest sobriety can consist with the greatest richness—richness without a flavor of gaudiness; and, beyond all, how the decoration of each fabric is suited to its use, and thoroughly subordinate thereto. The flat treatment of ornament for textile design, the conventionalized rendering of the graceful forms suggested by, but not blindly copied from, foliage and flowers, and all the varied intricacy of vegetable growth—the production, in short, of so subdued and harmonious an effect, both in form and in color, that the unobtrusive masterpiece of art gives to the eye a rest like that which it experiences in dwelling on the graver aspects of nature—such are the results of the exquisite sensibility to the power, and to the varied refractions of his rays, that the sun has bestowed on his dusky neighbors in the East.

For in this, we conceive, lies the secret of the truth and delicacy of the Oriental taste. East and west are mere comparative terms, accidents of geographical relation; north and south, tropical, subtropical, or temperate, are terms of positive import. Southern Japan, China, India, Persia, Arabia, regard the sun as he shines with a strength unknown in the shifting climate of Northern Europe. The optic nerves, as, indeed, the reasoning powers in general, are stimulated in those lands into a susceptibility unknown to the races who think more keenly than they feel. Repose from glare is the first luxury under vertical sunlight. Thus, by the very glory and brilliancy of his climate, the Oriental artist has been taught how to dip his brush in soft and harmonious hues. The quaint conventional forms into which he has tamed the luxuriance of decorative tracery may, in all probability, be due to the same law. Contrast and consent of color demand duly proportioned areas of display, and appropriate blending of the form and outline of those areas. It is thus that the Oriental patterns have grown out of the Oriental tints. We have this proof that such is the case. In the production of those Oriental people who are so essentially monotheistic in their creed, as to allow no likeness of any living thing to be pictured in their art, we find the patterns which we recognize as Oriental, alone to prevail. Every curve, every line, is conventional. But among those people, also Oriental, whom no religious motive withholds from portraiture or pictorial effort of any kind, side by side with subdued conventional forms, we find the wildest freaks of the grotesque. Michael Angelo never dreamed of such contortions (even in that vision of judgment, in which the chief western painters have allowed themselves the utmost license of anatomical *phantasmagoria*) as are common to the grotesque statuettes of Japan, or the foliated dragons of China. In all that tells of form and of motion alone, the Oriental taste, when unrestricted by the Koran, turns into the very wildest extravagance. The stiffness and reserve of that delineation of form which is made use of, for the express purpose of the harmonious distribution of color, in textile or ceramic fabrics, would therefore seem to have been produced by the instinct of the colorist, rather than by that of the draughtsman.

It is thus to Oriental art that we must

turn, for the best examples to be collected for any school which seeks the improvement of decoration, as an end rather than as an accident. The glories of Saracenic art were, it is possible, at their brightest, when the faith of Islam was yet in the conquering vigor of its youth. India has handed down her art traditions only from a date some two or three centuries antecedent to that of Arabian conquest. Persia had her artists when Babylon was ruled by Persian kings; nor has she lost the instinct of her craft. China, with her written history of 44 centuries, has been, at least in some respects, degenerating and receding for nearly a fourth of that period. Japan, so far as we can tell, has never been more vigorously alive than in her contemporary art. It is to Japan, therefore, that the philosophic student will look for valuable hints, and energetic stimulus, for the decorative artist of today. In metal and in clay, in silk and in other textile fabrics, in lacquer and in wicker, in all that comes under the name of paper, Japan strikes out, in rich profusion, productions which, so far from our being able to equal or to imitate them, often pass our comprehension, when we would inquire how they were produced. Her acrobats and her jugglers; her gymnasts, who hang from the roofs of the loftiest buildings, like monkeys or like birds; her wizard top-spinners, who make that ancient toy simulate the action of obedient intelligence, who give the apparent sportive life of the butterfly to a scrap of paper, and who address an English audience in a whistling dialect, that resembles the spring-tide gabble of our hedge birds, are not her greatest magicians. For her soil is a seat of living, decorative art; and they may best attain to excellence in the pursuit of ornamentation who graduate in that unique university.

The illustrated books which treat on Japan are few. There is an Italian account of the arrival at Rome of some Japanese princes, in the year 1585, printed at Venice in that year. "A Description of the Mighty Kingdoms of Japan and Siam," translated by Capt. Roger Manley, was printed in London in 1683. "Memoirs of the Embassies of the Dutch East India Company to the Emperor of Japan," were published at Amsterdam in 1680. There is a French work, by M. Titsing, illustrating the funeral rites and marriage ceremonies of this strange people, in the latter of which two attendants, called the male and female butterflies, play conspicuous parts. "The Manners and Customs of the Japanese of the Nineteenth Century," and "Japan Opened," are two compilations published in London. "The Capital of the Tycoon," by Sir Rutherford Alcock, is a recent original English work.

But any one who wishes, without visiting the great maritime empire of the Mikado, to form a clear idea of a portion of the human family, amounting to some 35 millions in number, whose elaborate civilization is as foreign to European notions as might be that of the inhabitants of another planet, should read the French work of M. Aimé Humbert, "Le Japon Illustré," which has been published during the present spring. The author, as Envoy Extraordinary and Minister Plenipotentiary of the Swiss Confederation, possessed unique opportunities of making himself acquainted with the interior life of the Japanese. The volumes are illustrated by nearly 500 "views, scenes, types, monuments, and landscapes;" some admirably reproduced from photographs, and some fac-similes of the wonderful drawings of the natives. The writer has regarded his subject rather from the social, than from the artistic, point of view; but many illustrations of the art of this extraordinary race may be found in perusing the work. Without adopting the form of a journal, M. Humbert appears to have written as he travelled; or, at all events, to have taken the outline of his route as that of his work. The result is, in spite of a certain want of system, a more life-like presentation to the imagination of this long-sealed empire than can be readily conceived of without reading the book. The shadowy and mystic dignity of the Mikado, the supreme and sacred sovereign; the rise of the power of the Tycoon, or Taïcoon (High Chief), recalling the history of the Merovingian *Rois Fainéants*, and the Mayors of the Palace; the struggle between the Tycoon and the fierce and powerful feudal princes; the manners of the two-sworded nobility; the sumptuous orgies of Sin Yosiwara, "the City of Vice," grasp the imagination like a fairy tale. A civilization of the utmost polish, free from the influences of either Egypt, Palestine,

Greece, or Rome, is a phenomenon of extreme interest.

The remarks we have made on the subject of Japanese art, and of the more recent literature treating of Japan, were written before the appearance in the English money-market of the Mikado, or supreme head, temporal and ecclesiastical, of that empire, gave to the subject the fresh interest of a topic of the day. In the recent revolution in Japan, of which M. Humbert supplies some of the details, this exalted personage appears to have returned from a condition more closely resembling that of the *fainéant* kings of France, of the Merovingian line, than any more modern parallel. Uniting, to some extent, the functions of Dalai Lama, Pope, and Emperor, this prince has recently suppressed the Siogounate, or vice-royalty, hereditary in the family to the noble known to us as the Tycoon ; and, as we have seen, taken the first step towards putting himself on the level of his European brother monarchs—*videlicet*, borrowing money. The amount of a million, ridiculously inadequate as it is towards the execution of any system of railways in the fertile and populous districts of the island empire, would, no doubt, have been immediately forthcoming on the ample security of the customs of the seaport towns. But some people never know when to cry "enough." If our information, which comes from a very central source, be correct, the margin between the price at which the French contractors took the loan themselves and that at which they offered it to the English public was so large (amounting to above 33 per cent.) that, an inkling of the fact having been given, people became unwilling to come in at the tail of such a very long *queue*. Thus we have seen the quotations fall more than 3 per cent. in a single day.

The question will naturally arise, if the Mikado wants English money, why not send it out under the direction of English engineers? The subject is too considerable to discuss in a hurry. One thing, however, is pretty plain from the experience of the few residents who know anything of the inner life of Japan. Foreigners who go to teach these gentlemen (who are, as matter of literature, fully up to our most recent improvements) must be prepared to carry their lives in their hands.

SOLAR HEAT.

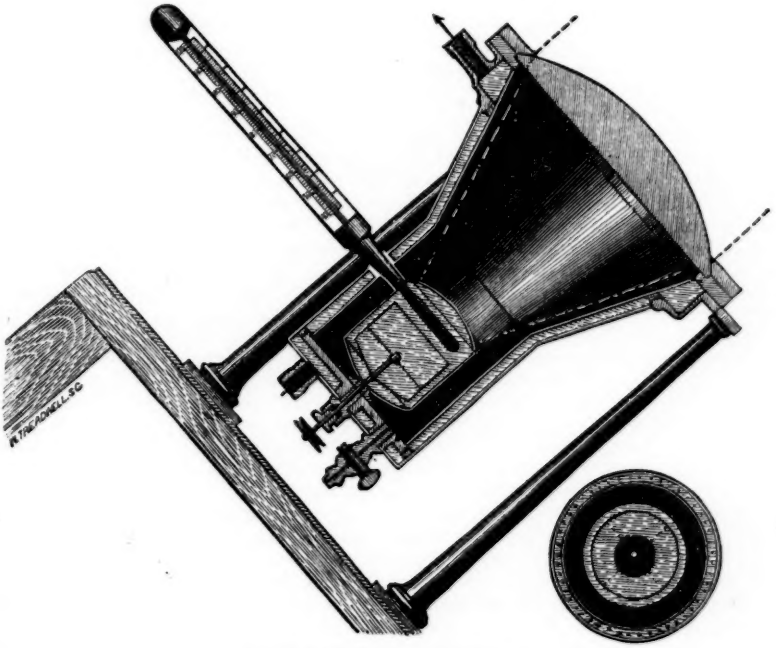
By CAPTAIN JOHN ERICSSON.

From "Engineering."

In a previous communication on this subject, I adverted briefly to some experimental engines which I have constructed in order to ascertain the practicability of employing solar heat as a motive power. I also adverted to the imperfections of the methods adopted by certain physicists to determine the dynamic energy of the sun's radiant heat. Having in the meantime perfected the necessary instruments for measuring, with desirable precision, the dynamic force of solar heat under the varying conditions governed by the changes of altitude, seasons, atmospheric temperature, and the presence of aqueous particles in the air—elements of paramount importance in judging of the applicability of the sun's radiant heat as a motor—I intend to lay before the readers of "Engineering" a series of articles giving a brief account of my researches, to be accompanied by accurate illustrations of the instruments employed.

Apart from ascertaining the dynamic energy of solar radiation by accurately measuring the units of heat developed in a given time under the varying conditions adverted to, I have extended my labors to the determination of the true intensity of the sun's radiant heat. Accordingly, I have instituted a series of observations which enable me to estimate the loss of intensity during the passage of the rays through the atmosphere. By adding this to the ascertained intensity of the radiant heat on reaching the surface of the earth, and before it is affected by terrestrial radiation, I can determine the actual intensity at the point where the rays enter the earth's atmosphere. My attention was originally called to the important subject of actual intensity of solar radia-

tion by reflecting on the limited amount of dynamic energy, about 5 units of heat per minute upon an area of 142 sq. in., exposed perpendicularly to the sun's rays, while the thermometer indicated 150° above Fahrenheit's zero, or 610° above absolute zero. Preliminary experiments, conducted very carefully, having disclosed the startling fact that the real intensity of solar radiation marks a point on the thermometric scale several hundred degrees below the freezing point of water, I resorted to the expedient of concentrating the sun's rays by such a method that the degree of concentration could be accurately measured. Investigations conducted in conformity with this method of determining the true intensity of the radiant heat, proved the temperature to be nearly identical with that shown by the preliminary experiments referred to. The extraordinary fact was accordingly established, that the intensity of the sun's rays before gaining by terrestrial radiation, is



ERICSSON'S SOLAR CALORIMETER.

so feeble that fluid mercury contained in an exhausted shallow vessel covered with a thin lens of about 50 in. focus, and exposed to the full power of a clear sun, will very rapidly become solid—provided the vessel is prevented from receiving heat from surrounding substances. It matters little whether the molecular action within the mass of mercury necessary to keep it in a fluid state is checked by the slower undulations of the solar ray, as waves of a rapid motion are checked by mingling with waves of less motion; or whether the molecular action within the mass of mercury is communicated to the surrounding cold vessel. In either case the reduced molecular force within the freezing mercury proves the inadequacy of the action produced by the sun's rays to maintain the metal in a fluid state.

Incidentally the experiments thus instituted to demonstrate the feeble power of solar radiation before its intensity is augmented by the intervention of the earth's atmosphere have established the fact that the surface of the moon, being devoid of any gaseous envelope, is at all times, even under the vertical sun of the long lunar

day, intensely cold. This apparently irrelevant subject will be considered hereafter. In the meantime, illustrations and descriptions will be presented of the instruments by means of which it has been satisfactorily demonstrated that before the temperature is augmented by the accumulation of heat which results from terrestrial radiation and the presence of the atmosphere, the sun's radiant heat, as before stated, marks a point on the thermometric scale several hundred degrees below the freezing point of water.

Before entering on a description of the accompanying illustration of my solar calorimeter (a denomination adopted in preference to "actimometer," as its object is only that of measuring the amount of heat transferred from the sun to the earth), I deem it proper to say that I object to the inferences which Pouillet, Mayer, and others have drawn from our knowledge of the dynamic force of solar radiation on a given surface of the earth. Unquestionably the amount of heat transferred from the sun to the earth may be accurately computed by means of the solar calorimeter; but to infer from the point thus established, that the sun parts with as great an amount of heat in *all* directions on an equal area as that which the earth during its orbital motion receives by intercepting and successively arresting the solar wave, is a mere gratuitous assumption. The practical mind refuses to accept a theory which involves such a vast disproportion between the means and the end, as the assumption that 200,000,000 times more heat is wasted than that which is employed to animate the planetary worlds of our system, more especially as the improbable and extravagant, not to say absurd, speculations which have been put forth by Mayer, Helmholtz, and others, all fail to suggest any mode of supplying the assumed enormous waste, which does not point to a speedy extinction of the central force. I will return to this subject on a future occasion, when the consideration of the new motor, the solar engine, will be in order.

M. Pouillet's pyrheliometer being now generally known through Professor Tyndall's work on "Heat as a Mode of Motion," the imperfections of that instrument may be pointed out without minutely describing the method adopted by the French physicist in determining the amount of dynamic force which the earth receives from the sun in a given time. The radical defect of Pouillet's instrument is, that it cannot be used during winter when the thermometer is below the freezing point, as warm water would have to be used, in which case the loss of heat by radiation and convection would be so great as to render the task futile, of accurately measuring the force of solar radiation. This defect of Pouillet's method is the more serious as the heat of the sun is most intense during the winter solstice for given zenith distances, not only on account of the diminished distance between the sun and the earth, but owing to the fact that the sky is clearer on a cold winter's day than during the heat of summer when the air is charged with vapor.

The loss of heat by radiation, in the pyrheliometer; loss of heat by convection, accelerated by currents of air; the absence of adequate means for circulating the fluid contained within the heater; the rude method of keeping the instrument perpendicular to the sun with the hand, not to mention the disturbing influence of respiration and the radiation from the operator's body, are self-evident defects. Nor can we pass unnoticed the want of any direct means of ascertaining the depth of the atmosphere through which the radiant heat passes at the moment of measuring its energy. I need scarcely point out that computations based on *latitude*, *date*, and *exact time*, are too complex and tedious for investigations in which the principal element, the depth of the atmosphere, is continually changing.

It will be well to state at the outset that the solar calorimeter, and all my instruments constructed for investigating the mechanical properties of solar heat, are attached to a table which swings upon a horizontal axle, and which rotates round a vertical pivot, appropriate mechanism being applied for regulating the combined vertical and lateral movement in such a manner that the top of the table, composed of a heavy brass plate accurately faced, is at all times during observations kept perpendicular to the central ray of the sun. Hence, instruments whose base is at right angles to their vertical axis, may be secured at any point of the face of the rotating table, without further ad-

justment. A graduated arc is attached to one end of this table, provided with an immovable index ; consequently, the sun's zenith distance may at all times be ascertained by mere inspection, a very great convenience in an investigation which at every instant is dependent on the changing depth of the atmosphere through which the sun's rays pass. As this depth bears a fixed relation to the sun's zenith distance, it may of course be accurately determined by noting the position of the fixed index on the graduated arc ; but as there is no time during investigations of this kind for computations, as already pointed out, I have constructed a graduated scale provided with a movable radial index, which, by being brought to the division corresponding with the observed zenith distance, shows the depth of atmosphere. It is proper to observe that in constructing this scale I have assumed the earth to be a perfect sphere of 3,956 miles radius. The error resulting from this assumption is, however, so trifling, that the described graphic method of ascertaining the depth of the atmosphere may, without appreciable discrepancy, be employed in all latitudes. The *solar calorimeter* consists of a double vessel, cylindrical at the bottom and conical at the top, an 8 in. lens being inserted at the wide end in the manner shown by the illustration. The interior is lined with burnished silver, and the space between the two vessels is closed at the top and bottom by means of perforated rings, as shown in the transverse section, the object being to distribute equally a current of water to be passed through the space between the vessels. Nozzles are applied at the top and bottom of the external vessel, of suitable form to admit of small hoses being attached. A stopcock with coupling joint is applied at the bottom, communicating with the interior of the calorimeter, and connected with an air pump for exhausting the same. A cylindrical vessel, termed heater, with curved top and bottom, composed of polished silver, is secured in the lower part of the instrument, and provided with a conical nozzle at the top, through which a thermometer is inserted from without. Within the lower part of the heater is introduced a centrifugal paddle wheel, surrounded by a cylindrical casing divided in two compartments by a circular diaphragm, the lower compartment containing four radial wings or paddles, the diaphragm being perforated in the centre. The centrifugal paddle wheel revolves on an axle which passes through a stuffing-box applied at the bottom of the double vessel, the rotary motion being imparted by means of a pulley secured to the lower end of the axle. The operation of this wheel, intended to promote perfect circulation of the fluid within the heater, is quite peculiar. It will be readily understood that by turning the wheel the centrifugal action of the fluid produced by the rotation of the paddles will draw in water downwards through the central perforation of the diaphragm, and force the same into the annular space round the casing of the wheel ; thus an upward current will be kept up through this annular space uniform on all sides. This current, after reaching the top of the heater, will then return, first entering the open end of the casing of the wheel, and ultimately the central perforation of the diaphragm. I have been thus particular in describing this system of promoting uniform circulation within the heater because a proper indication of the actual mean temperature of the water contained in the same is the all-important condition on which depends the accuracy of the determination of the number of units of heat developed. It only remains to be pointed out that the lens, which is so proportioned as to admit a sunbeam of 52 sq. in. of section, is placed at such a distance from the heater that when the concentrated rays reach the upper end (painted with lamp-black) they are confined to an area of 3.25 sq. in., precisely $\frac{1}{16}$ of the sectional area of the sunbeam which enters the lens.

It will be obvious that the concentration of the radiant heat on an area of only $\frac{1}{16}$ of that of the section of the sunbeam, removes a very difficult disturbing element from the investigation, viz., the great amount of heat radiated by the blackened surface of the heater, which, in the pyrheliometer, is 16 times greater than in the solar calorimeter. But this is not all ; while the 16 times more extensive blackened surface of the former is exposed to currents of air, the disturbing effects of which can neither be controlled nor computed, error arising from convection is wholly removed from the latter, because

the reduced blackened surface of the heater receives the concentrated radiant heat within a vacuum. The loss of heat at the bottom and sides of Pouillet's instrument, caused by convection and currents of air, is likewise wholly removed in the solar calorimeter by the expedient of operating within a vacuum. It will be seen, therefore, that the loss of heat by convection and currents of air has been wholly obviated in the solar calorimeter, while the loss caused by radiation from the blackened surface of the heater has been reduced to a mere fraction. It may be contended, however, that the loss by radiation of the polished heater against the interior polished surface of the calorimeter, although minute, is yet appreciable; and that some heat will be lost by conduction at the points where the heater joins the external vessel. Even these trifling sources of error, it will be seen presently, have been removed by a new method. A force pump and capacious cistern containing water are arranged near the calorimeter, an uniform temperature of 60° being kept in this cistern by the usual means of a warm and cold water supply. By appropriate hose and the force pump mentioned, a constant current is kept up through the space between the internal and external casings of the instrument; hence, every part of the latter may be brought to an uniform temperature of 60° in a few minutes. The process of measuring the solar energy is conducted in the following manner: The thermometer being withdrawn, the heater is charged with distilled water of a temperature of about 45°, after which the thermometer is again inserted. The table supporting the instruments should now be turned towards the sun and the paddle-wheel put in motion. The indication of the thermometer must then be watched, and the time accurately noted when the mercurial column marks 50 deg. on the scale, the observation continuing until the thermometer marks 70 deg., at which point the time is again accurately noted. The experiment being then concluded, the table should be turned away from the sun. It scarcely needs explanation, that during the elevation of the temperature of the water from 50 deg. to 60 deg. the instrument radiates *towards the heater*, and that while the temperature rises from 60 deg. to 70 deg., the heater radiates *towards the instrument*. In each case the amount of heat radiated, that is, the gain and the loss, is almost inappreciable, since both the heater and the surrounding internal vessel are composed of polished silver. The amount of gain and loss of heat by *conduction* at the points where the heater joins the surrounding vessel, if appreciable, evidently balance each other in the same manner as the gain and loss by radiation.

The weight of distilled water at 60 deg. contained in the heater, and the weight and specific heat of the materials which compose its parts, being ascertained, the number of units of heat necessary to elevate the whole 20 deg. may be readily calculated. To this must be added the percentage of calorific energy lost during the passage of the sun's rays through the lens. The sum will represent a permanent coefficient for each particular instrument which may ever afterwards be employed to determine the dynamic energy of the sun's radiant heat. Obviously the indication will be equally correct during the winter solstice in a northern latitude with the mercurial column at zero as during the summer solstice within the tropics, when the thermometer marks 100 deg. in the shade.

It must not be supposed that the same difficulty presents itself in ascertaining the loss of calorific energy of the rays of heat as that involved in a determination of the retardation which rays of light suffer during their passage through a lens. In order to determine the former we have only to compare the units of heat developed by the direct action of a sunbeam of a given section, with the number of units developed by another sunbeam of equal section during an equal interval and at the same time, acting through the lens, the retarding influence of which we desire to ascertain. I have constructed an instrument for this purpose by means of which the diminution of the calorific energy of the sun's radiant heat can be accurately measured for all lenses not exceeding 8½ in. diameter. This instrument will be delineated and explained at the proper time.

Referring to the experiments which have been made with the solar calorimeter, it is specially worthy of notice that the sun's energy as shown by this unerring mode of measuring the force actually

transferred to the surface of the earth, is never regular. The force of the radiant heat, call it molecular action, indicated by the increment of the temperature of the fluid in the heater of the instrument, is continually oscillating. At first I attributed this circumstance to invisible masses of light vapor passing through the atmosphere. More recent observations induce me to think that want of constancy in the evolution of the heat at the source may possibly be the true cause.

SUN POWER.

From "Engineering."

Upon another page we publish the first of a series of articles, from the pen of Captain Ericsson, upon the investigation of solar heat, and the means whereby the power so unequally distributed upon our planet can be made useful.

This question, novel and startling as it was when it was first proposed some years since, may now be considered to have assumed a practical form—thanks to the extended and careful experiments conducted by the author of these articles. The result of his experiments, pointing as they do to a means whereby the arid sunburnt portions of the globe are in possession of a vast inexhaustible source of power that may be utilized if science and mechanical skill be properly directed, cannot be overrated. It is idle, now that investigation has proved its possibility, to laugh at the instructor who points out what may be achieved in the immediate future. The fervent heat which to-day pours down upon our tropics, in the remote past bathed our now temperate zones, and, with atmospheric conditions favorable, an immense reservoir of power for future use was stored up. We are drawing now upon those stores hidden by an economical dispensation for wants to come, but a similar heat which was thus concentrated is distributed upon a portion of our planet now, only to destroy and make arid regions which might be placed on an equality with the more fortunate regions could that heat be converted into power, by which the desert would be turned into a garden.

Captain Ericsson has been, and is, laboring to this end, and the result of his experiments, so far, while showing the vast power to be obtained, points out likewise the means to utilize it. Extending through a series of years, his experience has gradually been brought into form, and it is the result of this experience that we shall have pleasure in laying before our readers, in a series of articles, that will contain the substance of an elaborate volume Captain Ericsson proposes, as soon as possible, to publish. But as a long delay will be involved in the production of this book, and as the question is one of too great importance to admit of delay, his investigations will appear in the announced form. In laying them before our readers, we must state, for the benefit of those who are ignorant, and those who know will confirm our assurance, that in the investigation of this question, and the publication of its results, Captain Ericsson has but one object—that of being useful. His life, and long professional career, has been so crowned with honor that he needs no more, and it is simply in the hope and expectation of conferring an universal, almost an immeasurable benefit, and not with any prospective view of fame or profit, that he has taken up and is pursuing these especial labors.

IRON AND STEEL NOTES.

The New Tariff.—We give below the changes made by the new tariff in the duties on Iron, Steel, and Metals, and the manufactures thereof, to go into effect January 1, 1870. Articles of these classes not mentioned remain as before:

On iron in pigs, $7 per ton.

On cast scrap iron of every description, $6 per ton.

On wrought scrap iron of every description, $9 per ton.

Provided, That nothing shall be deemed scrap iron except waste or refuse iron that has been in actual use, and is fit only to be re-manufactured.

On sword blades, 35 per centum *ad valorem*.

On swords, 45 per centum *ad valorem*.

On steel railway bars, 1¼ cent per lb.; and on all railway bars made in part of steel, 1 cent per lb.: *Provided*, That metal cemented, cast, or made from iron by the Bessemer or pneumatic process, of whatever form or description, shall be classed as steel: *Provided*, That round iron in coils, three-sixteenths of an inch or less in diameter, whether

coated with metal or not so coated, and all descriptions of iron wire, and wire of which iron is a component part, not otherwise specifically enumerated and provided for, shall pay the same duty as iron wire, bright, coppered, or tinned: *And Provided further*, That steel, commercially known as crinoline, corset, and hat steel wire, shall pay duty at the rate of 9 cents per lb. and 10 per centum *ad valorem*.

On rough or unfinished grindstones, $1.50 per ton; on finished grindstones, $2 per ton.

On hair pins made of iron wire, 50 per centum *ad valorem*.

On sporting gun wads of all descriptions, 35 per centum *ad valorem*.

On manufactures or articles of nickel, albata, or white metal, argentine, German silver, and the like mixed metals, and of aluminum and its alloys, 45 per centum *ad valorem*.

The following articles, among others, are added to the free list: bells broken and bell metal broken, and fit only to be remanufactured; anthracite coal; emery ore or rock, not pulverized, not ground.—*Iron Age*.

STATISTICS RELATIVE TO MINING IN EUROPE.—The number of furnaces in Europe is about 5,000, of which 1,086 are in Great Britain, 1,177 in Prussia, 926 in France, 481 in Belgium, 436 in Austria, 374 in Russia, 361 in Spain, 255 in Sweden and Norway, 193 in Saxony, 150 in Italy, and 136 in Bavaria.

Of iron the yearly make is about 157,373,000 cwt., of which 91,630,000 is made in Great Britain; 23,560,000, France; 10,521,000, Prussia (old provinces); 8,790,000, Belgium; 7,134,000, Austria. 4,950,000, Russia; 4,150,000, Sweden and Norway; 1,600,000, Italy; 824,000, Spain; 718,000, Bavaria; 617,000, Province of Hanover; 451,000, Saxony; 455,000, Wisbaden; 263,000, Netherlands; 206,000, Wurtemburg; 269,000, Brunswick; 155,000, Cassel; 139,000, Hesse; 120,000, Portugal; 101,000, Baden; 20,000, Denmark; and 20,000, Greece.

The worth of the total produce of iron in Europe amounts to about 966,000,000 fr. (it exceeds in worth all the remaining metals by nearly three times); of this amount Great Britain makes 412,000,000 fr.; France 197.000,000; Prussia, 80,000,000; Belgium, 80,000.000; Austria, 55,000,000, Sweden and Norway, 45,000.000, Russia, 41,000,000; Italy, 14,000,000; Spain, 8,000,000; Switzerland, 3,500,000; Netherlands, 200,000; and of the rest of Europe, about 3,500,000 fr.

By this valuation the worth of 1 cwt. of iron in Sweden and Norway is 10 fr. 80c.; Switzerland, 10 fr.; Spain, 9 fr. 70c.; Belgium, 9 fr.; Italy, 8 fr. 70c.; France, 8 fr. 50c.; Russia, 8 fr.; Austria, 7 fr. 70c.; Prussia, 7 fr. 60c.; in Great Britain, 4 fr. 50c.—*Bulletin of the American Iron and Steel Association*.

THE "WASTE" AT OUR IRONWORKS.—Economic iron making is of very recent growth. Those who have examined old mounds near the site of the earliest ironworks are astonished at the waste shown in carrying out the primitive details of extracting iron from mine stone, a much larger percentage of iron remaining in the refuse than was extracted. This was notably the case with the Romans. At Cinderford and other places on the borders of Wales the "cinders" have proved of great value, and all are well nigh utilized. This waste was not confined to the Romans. We have examined cinders from old workings dating from the time when the Sussex ironmaster migrated into Wales, and also at the remains of furnaces placed by Mushet and others, as far back as the Elizabethan era, and the same fact is observable. The means then employed were rude and inefficient, and, coupled with this, there was an evident haste in the arrangements, the desire being to obtain as much metal as it was possible to gain in the least amount of time. Coming down to a later period, we find, in the early annals of the Plymouth Works, that the refuse cast aside, and made into tips, contained 40 and sometimes 50 per cent. of iron. Until Mr. Anthony Hill's patent this remained unworked, but thanks to him, the method of working it was discovered, and the huge tips were soon levelled and used up.

Penydarran Works, more than any in modern times, still retain amongst its ruins—now, we are glad to state, in progress of re-establishment—the evidences of great, we might almost say wilful, waste. Started at a time when iron making was most profitable, little details of economy were overlooked, iron mine was abundant; wood, and after that coal, equally so. As long as ironmasters found immense returns coming in they were content, and thus, while colossal fortunes were being made, many small ones were lost in absolute waste. A laughable incident of this has been related to us of Alderman Thompson, when part owner of Penydarran. He had his attention called to the looseness shown in the works, and was accustomed on every visit to bewail his fate, and say he should be ruined. One day he gathered some nails scattered on the ground, and repeated his doleful cry: "This shocking waste! I shall be ruined." As he was saying this he entered John Rees' lodge. John, who was a bard as well as a workman, finding himself lazily inclined, perhaps in a poetic mood, felt disinclined to go to the coal heap to replenish his fire, and was occupied in raking up the cinders with his hands. "Ah!" exclaimed the Alderman, "here's a careful man at last!" and ever after regarded him with favor.

At these works, and on the whole estate connected, we have evidence of the most wilful waste. The iron—and always the best—used in the building was something enormous; where slate and wood, or stone, would have done better. Sheet iron was brought into requisition. The supply of coke to the blast furnaces, containing even a greater percentage of iron than the "waste" which Anthony Hill found so valuable.

The estate, extending over several miles, still retains the old sign of extravagance. At the bottom of long-disused tips, weighty iron trams—now rusted and decayed—remain, left there years ago by men too lazy to pull them up. You come to a cottage by the side of a little stream, and a fine piece of sheet iron has been improvised into a bridge. Old rails fence off the approach of another, or are made into a "stile." At the top of an incline, massive slabs of iron remain in profusion, cast aside as so much rubbish, and almost concealed by earth and weeds. And you have only to remove a little of the tips to find iron nodules abundant enough to make the mounds so many valuable "mines" to the enterprising ironmaster. When we see these evidences—so abundant among us now—we have a good idea afforded of the waste that was exercised in the daily round by the workmen. It is a fact that numbers of men at Penydarran fifty

years ago earned £20 a month; another fact, that the puddlers kept a keg of rum on tap on the works, and that the earnings were squandered profusely. Such men, neglectful of their own means, would pay less regard to the interests of their employers, and scatter his means with the freest hand. Of late years this has been corrected to a great extent. There is a methodic manner now observed, in strong contrast to the past. Lime, coke, and limestone, are weighed carefully; every ounce is economized, and the results—pig and rail, or bar—brought under the same arithmetical precision. Coal, too, once used in profusion, is now economized; and this is seen forcibly at Dowlais. Formerly the largest and best coals were used, while small coal was cast aside as worthless. Now, by the discovery of the use of waste gases from the blast furnace, the small coal is made to do duty instead of the other, and the large and best coal is sold in great quantities. We have little hesitation in stating that within the last 10 years the Dowlais coal-fields have been made to form no inconsiderable source of revenue to the proprietors. This is a step in the right direction, and though much waste still continues in the various ironworks and steelworks, the subject is now under thoughtful scrutiny, and we may hope to see the loss reduced every year.—*The Engineer.*

From Sheffield, England, our latest advices say: The demand for steel, both at home and abroad, continues brisk, and more is now being sent to America than for many months past. It is feared, however, that we have not yet heard the last of what was so long known as "the steel difficulty," despite the recent decision of the General Appraiser in New York as to the correctness of our manufacturers' invoices. The demand for Bessemer steel rails, and for railway material generally, is exceedingly brisk; and so great and many are the orders for rails that Bessemer steel is being sent to Sheffield to keep pace with the demand. The armor-plate mills are well employed, though this department is scarcely as active as it was, and the same remark applies to the rolling-mills. There are but few heavy castings in hand. The file trade has recently become increasingly active, but as yet the orders are not sufficient to find employment for the whole of the workmen, some of whom continue to work on short time. The saw trade, also, which has been depressed for many months, has of late been improving, but at present there is nothing like briskness, and it is to be feared that the welcome change which this branch is now experiencing will be only of a temporary and partial character. Some good orders are in hand for several descriptions of edge-tools. —*Bulletin of the American Iron and Steel Association.*

Improved Blast-furnace.—Messrs J. and G. Onions, of Dudley Port, have recently completed the erection of a blast-furnace, designed to effect the consumption of the waste gases, after the manner of those in the Cleveland iron district. The furnace was commenced in January, and was put into operation ten days ago. It is of much larger dimensions than those ordinarily in use in the Black Country, being 50 ft. high, and 13 ft. 6 in. in diameter at the bosh. The mouth is closed, but 2 massive tubes carry the smoke and flame to the hot-air apparatus and the boiler respectively. By this plan the saving of fuel and labor is, of course, very considerable. Mr. Onions estimates the saving of slack at 120 tons per week, of the aggregate value of £30. The following laborers are also dispensed with—four firers, four boat-unloaders, one bridge-stacker, one coal-wheeler, and one ashes-wheeler. There is no escape of smoke whatever, and the furnace contrasts strangely with those around it, each of which is polluting the air with sooty volumes by day and night. We noticed 7 tuyeres on the furnace; ordinary furnaces have 5. By having the greater number, however, a more equal distribution of the blast is effected. The furnace is now producing all No. 1 gray iron, for melting purposes, but it is intended ultimately to confine its produce to forge-iron. The present rate of production is 180 tons per week, being nearly double that of the old-fashioned Black Country furnaces. The cost of the new furnace, in erection and plant, is about £2,000 more than those on the old principle. The contiguous buildings are all on a complete and substantial scale. The stack is 150 ft. high, 9 ft. clear inside at the top, and has a base of 16 ft. sq. The design is entirely by Mr. Onions, and it infringes no patent right whatever. Many of the principal ironmasters in the district have been to see the furnace in operation, and express themselves satisfied with its success.—*London Mining Journal.*

The number of tons of railroad iron rolled in this country during the last four years was as follows:

1866.....	430,766	1868.....	516,000
1867.....	462,108	1869.....	580,000

The Pennsylvania Steel Works, for the manufacture of Bessemer steel rails, at Baldwin, 3 miles below Harrisburg, are the largest of the kind in the United States. The Bessemer Building is 114 ft. long by 100 ft. wide and 25 ft. high. The adjoining building is 80 ft. long by 52. ft. wide and 39 ft. high. The engine and boiler building is 133 ft. long by 52 ft. wide and 15 ft. high, besides a blowing engine room 66 ft. by 22 ft. The buildings are of blue limestone, roofed with slate.

RAILWAY NOTES.

The Westinghouse Atmospheric Brake.—This brake, the invention of Mr. George Westinghouse, of Pittsburgh, has passed the experimental stage. In the judgment of the managers of the most of our leading Western, and of a few of the Eastern lines, it is regarded as a decisive solution of that most difficult of all operating problems—the sudden stopping of the heaviest possible train at the highest speed without inconvenience to passengers, and with no appreciable injury to machinery. When a short train, too, going at high speed can be brought to a rest in running its own length, the limits of the practicable would seem to be attained.

The record of the tests to which Mr. Westinghouse has submitted his brake is familiar to the readers of the "Review,"—as is also the description of the device—full particulars having been given, especially in our issues of October 7th and December 2d, 1869.

The purpose in the present article is, not to recount these, but to state the facts concerning its

introduction, and to give a summary of the excellencies which all our managers who have adopted it unite in ascribing to it. The number of engines and cars to which the apparatus has been applied is shown in the following :

	Engines	Cars.
Pennsylvania Central	50	200
Pittsburgh, Fort Wayne & Chicago	10	30
Chicago & Northwestern	2	11
Chicago, Burlington & Quincy	8	20
Chicago, Rock Island & Pacific	2	6
Union Pacific	19	50
Michigan Central	10	25
Jefferson, Madison & Ind	2	13

The Pan Handle and Lake Shore and Michigan Southern are running each one train. We have conversed, personally, with the most of the managers of the roads above named, and the following is a statement of the conclusions to which we have come :

1. Many devices, theoretically sound, fail to realize the expectations of the inventor from the fact that too little "margin" has been left in a complicated apparatus for wear and tear. Necessary repairs must neither "cost more than they come to" in money ; nor must they too frequently or too long withdraw the apparatus from service. Its working parts identical with those of the locomotive, attached to the existing brakes of the car which it works by the most simple and durable apparatus—the Westinghouse brake perfectly meets the requirements of every-day trains. In fact, we speak advisedly when we say that its use involves less wear and tear than that of any other equally important portion of the machinery of the train. The maximum speed of the air-pump piston attached to the engine is but 100 ft. per minute ; the piston under the car, working but once at each stop, practically, can never wear out ; the hose—heavy india-rubber—slack between the cars, exhibits no signs of wear in cases where it has been used a year and a half ; while its couplings—which are automatic, leaving the brake applied even to a detached car—are so simple and so strong that they cannot be injured except by heavy hammering.

2. It secures instant application of the brakes to every wheel of the longest train, the pressure on all the wheels being "elastic" and uniform. Under the control of the engineer, the force with which it is applied can be graduated from zero to the full power. So that not only can a train at high speed be instantly arrested, but slacking of speed can be accomplished on down grade, at bridges, etc.—just the amount necessary, the train being held at any given speed, fast or slow.

3. There is, thus, no superfluous expenditure of force, and no unnecessary wear and tear. The uniformity and steadiness with which the brake is held prevents the wearing of "flat spots" in the wheel—which under the old system sometimes ruins a wheel in a single trip ; all sliding of the wheels is done away with ; the safety of the train in making frequent stops is not only insured, but the making of running time is secured, and the comfort of the passengers is greatly increased, as the application of the brakes is never heard or felt.

4. The advantages of a system by which the engineer, with the same act by which he now whistles "down brakes," can himself stop the train, although obvious, may be here suggested in the light of results. At from 30 to 40 miles per hour a train runs at a speed of about one car length per second ; and this brake would bring it to a rest in 6 car lengths. On the Pan Handle line, about 5 weeks ago, the train was approaching the station at Burgettstown, when the engineer discovered the rear end of a freight train 300 ft. ahead. Running at the rate of 25 miles per hour on a down grade of 58 ft., he applied the brake and stopped his engine within 25 ft. of the train. In another instance, going around a curve on a down grade, a man was observed on a trestle ahead, and his life saved. The instances in which live stock on the track are saved, and accidents to the train at the same time avoided, have been very numerous. In one word—this brake is liable at any moment to be the means of saving life ; while the security of property (saying nothing about diminished wear and tear to the train) which it affords must pay for its introduction many times over on any great road.

5. Finally, the apparatus is so identical in principle with the machinery of the locomotive that it can be applied, in a very short time, to *any* engine. As we have stated, it works in connection with the hand brakes—as also *with the Miller platform*. The charge for fitting a train with it is :

Locomotive	$300
Tender	25
Per car	100

Shops for manufacture and repair have been erected at Pittsburgh. The Company have already turned out $70,000 worth of work ; have $100,000 more (on order) in hand ; and are ready to fill all orders promptly. All the parts of the apparatus are made on uniform pattern, so that duplicates of any piece can be at once obtained.—*Chicago Railway Review.*

IMPROVED BOGIE ENGINES AND ELASTIC SELF-ADJUSTING RAILWAY CARRIAGE WHEELS.—Mr. George Smith, M. Inst. C. E., of Belfast, has just introduced to the public some improvements in bogie engines, which consist of an arrangement of segmental-headed pins or bolts attached to framings of the engine and bogie, and so constructed as to allow of a true motion round the centre, and admitting also of a compound transverse and circular motion, by means of slots made in the slides. The engine, carriage, and bogie frames are always in contact, and sliding upon each other. The weight is equally distributed amongst the wheels of the bogie by means of a system of compensating levers connected to the springs.

The novelty of these wheels consists in the body, hoops, spokes, or discs being suspended to the tyres. By such an arrangement the tyres are in compression as well as the body, spokes, or discs, while the hoop is always in tension ; the reverse in principle to the constructions at present adopted.

The advantages are cheapness, lightness, durability, greater safety to the trains, especially at high speeds, as the tyres cannot separate or break from the body, hoops, spokes, or discs of the wheels; nor can they mount the rails. As the tyre shears instead of biting, there are less jolts, less tear and wear to engines or carriages, and permanent way ; no skidding or sliding or lateral concussions, nor any necessity for double rails at sharp curves. The improvement also prevents torsion to cranks and axles. As the tyres regulate themselves to the irregularities of the permanent way, there will be

less straining or vibration of the bridges on account of the elasticity of these wheels. Lastly, it is found that with these wheels in use, there is no need to loosen the ballast, as is often done, to give elasticity to the rails, so as to lessen the hammering of the rigid wheels as at present constructed. The jolts and jars now felt in going over loose joints of the rails, and especially on bad, rigid, or frozen roads, are greatly, if not entirely prevented (a boon to passengers, especially in long journeys). The arrangement also enhances the safety of the body's spokes, or discs of the wheels, whether made of wrought or cast iron; as they are loosely suspended in elastic steel or iron hoops, they may expand or contract without strain or contortion to the several parts, under all changes of temperature, whereas in the tyre and body of the old wheel there is a constant danger, in consequence of their unequal expansion and contraction, more particularly in sudden changes of the weather. These improvements are obtained by suspending the axle from the top of the wheel by means of an elastic steel or iron hoop, which allows for any inequality in the rails, while at the same time the tyre is free to revolve independently of the body of the wheel.

The disadvantages or defects of the present wheels are their tendency to mount the rails, and their liability to sliding and lateral concussions, thereby occasioning oscillations of the train, matters which not only engineers but ordinary railway passengers cannot fail to have observed; but, beyond these defects, and not so obvious to the uninitiated, are loss of power in traction by the unequal wear and tear of the tyres; also unequal expansion and contraction of the tyres and body, torsion of the cranks and axles; and these defects are greatly increased should the frames of the engine or carriages get out of the square by twisting or straining, leaving out of the question bad roads, unequal lengths of the rails at the various curves, all of which have to be taken into consideration, independently of the straining and vibration of the bridges when passing over, as well as the enlargement of the engine tyres, when they have to be taken off and re-set. There is also the ever-present danger of the tyres, when at high speed, separating or breaking from the body of the wheel, to the destruction of the train, and danger of life, all owing to their being fixed on the axles.

The object of the self-adjusting, elastic, or suspended wheels is to obviate the above-mentioned disadvantages or defects of the fixed wheels now in use, to obtain which is to have the elasticity as close as possible to the working-point between the wheel and the rail, as all unnecessary weight interposed between the axle and the rail is adding inertia, thereby increasing the wear and tear of the wheels and rails.

THE ARMSTRONG STEEL FROG.—"The Chicago Railway Review" says: It is claimed that the usual steel frog cast in mould is open to objections,—that, during sudden changes in temperature or when subjected to severe concussion or heavy weights it oftentimes breaks, and from the necessarily brittle nature of the casting is liable to chip and flake under ordinary wear; and that it is at the same time extremely unyielding and rigid—characteristics which are by many experienced engineers considered elements of much danger when trains pass over them at great speed.

In the forged steel frog of Messrs. Armstrong, it is sought to avoid these objections. The metal, from being hammered, becomes fibrous instead of granular, giving a strength and toughness which render it impossible for the frog to be broken or to chip in wearing. Moreover, this process gives to the frog the nature of a spring, doing away with the rigidity often felt in running.

The arrangement for fishing the frog—at both its ends—to the track rails would seem to be a vast improvement on that of slotting the rails usually employed. This fishing of the frog is very highly esteemed in Europe; indeed there is not a frog laid in any railroad line that has not the fish bar fastening applied. Messrs. Armstrong & Co. desire us to state that they specially guarantee that this frog shall endure double the ordinary wear and tear—or more specifically, that it shall wear for *ten years, with 80 trains a day passing over it.*

We hear that this invention is meeting with a very extended sale in all parts of the United States. Our railway engineers are seldom slow to acknowledge and adopt meritorious inventions whenever a wise and prudent economy or advantage can be gained thereby.

WE stated a short time since that the plan patented by Mr. Bessemer for preventing sea sickness by constructing a chamber for passengers on board steamers suspended, on the same principle as the compass, was about to be practically tested, and that Messrs. Maud lay were constructing a screw steamer of 300 tons burden upon the principle. We understand that the steamer will be ready for its trial trip in November next. Should the result equal the anticipations of its inventor, and of all who have seen the models and drawings, it must lead to the construction of similar ships capable of taking all the traffic between this country and Europe. Two of these, it is calculated, could be built for £130,000, of great size, fitted with the most luxurious accommodation, and of sufficient power to make the Channel passage in 60 or 70 minutes. In the event of the process being found perfect, Mr. Bessemer intends, we believe, to offer the use of it first to the various interests primarily concerned, such as the English continental railway lines, etc., and, failing any arrangement with these, to organize a general system of international communication with independent capital. As respects the future prospects of the railroads in connection with Ireland on the one hand, or the Continent on the other, the importance of the approaching trial can hardly be overestimated.—*Railway News.*

ORDNANCE AND NAVAL NOTES.

THE FRENCH "MITRAILLEUSE."—To destroy your enemy in the shortest time, in the easiest manner, and at the least possible expense, is the first maxim of war. The stone that whistled from David's sling, the bullet of the "zundnadelgewehr," and the volley of the "machine gun" had all the same object. Since the days of Roger Bacon the aim of all improvements in fire-arms has been to carry the greatest possible number of deaths to the greatest possible distance. Grape, canister or case, and shrapnel, all contain bullets, and are all means for multiplying deaths. The field-gun mows down its hundreds by showers of case at close quarters, or at longer distances rains bullets from the bursting shrapnel. The mitrailleur, or

machine gun, on the contrary, sends a large number of small projectiles independently, and with precision, to a considerable distance. We may divide arms on the latter principle into two classes —1st, those which discharge their bullets from a single barrel, fed by a many-chambered breech; and, 2dly, those in which each cartridge has its corresponding barrel, the charging and discharging of which is direct, and more or less simple. It is obvious that for rough usage and continuous firing it is better that a large number of rounds should be fired from a considerable number of barrels so placed as to support each other and add strength to the whole machine. The French Mitrailleuse, as well as the Belgian Montigny, belongs to the second class, and the following brief description is equally applicable to both arms:—

"The machine-gun consists of a cluster of barrels either bound together or bored out of the solid, and mounted on the same principle as an ordinary field-gun. At a few hundred yards, indeed, it would be difficult to distinguish between these weapons as far as outward appearance goes. To the barrel is attached a massive breech action, capable of being opened and closed by a lever. In the Montigny arm the cartridges are carried in steel plates, perforated with holes corresponding in number and position to the holes in the barrel. This steel plate, in fact, forms the "vent piece" of the system. The central-fire cartridges being dropped into the holes in the steel plate, stand out at right angles from it, and the plates, thus ready charged, are so carried in limber and axletree boxes specially fitted for their reception. When the gun comes into action the breech is drawn back, a steel plate full of cartridges is dropped into its corresponding slot, and the breech block thrust forward and secured. The gun is now on full-cock, and contains from 30 to 40 cartridges, which are fired by a "barrel organ" handle, either one by one as the handle works round click-click, or in a volley by a rapid turn of the wrist. When the gun is empty, the breech block is again withdrawn, the steel plate carrying the empty cartridge cases lifted out, and a fresh plate dropped in, if necessary. The advantage possessed by the machine-gun over infantry fire is that it is never in a funk. Bullets may rain around, bursting shells may fill the air, still the 37 barrels of the Mitrailleuse shoot like one man, and at 800 or 1,000 yards will pour volley after volley of deadly concentrated fire into a circle of from 10 ft. to 12 ft. in diameter. No boring or fixing of fuses is required, and the whole operation is performed so rapidly that two steady, cool men could maintain a fire of 10 discharges per minute. On the other hand, the Mitrailleuse could not well compete with the field-gun, and it is with this weapon it will assuredly be met. Its bullets would have comparatively slight effect at the ranges at which field artillery projectiles are perhaps most effective, while its size would offer a very fair mark to the gunner. The foreign press are welcome to write *fanfaronnades* about the sudden death of wretched horses at incredible distances. This is peace practice. The horses came from the knacker's yard, not from the banks of the Elbe, and there were no Uhlans sitting on them. We are also tempted on such occasions to take the square root of the reported distance as the actual range. The future of the Mitrailleuse, however, depends on coming facts. The day's experiments are over; there are hundreds of machine-guns trundling towards the Rhine. The drum-like roll of their volleys may ere long be heard in the vineyard of Rudesheim, or on the edge of the Black Forest; and the "thud" of the bullet may come from something softer than a wooden target. Yes, the machine-gun is *en route* for the Rhine; the experiments will now be on a gigantic scale; and Mr. Cardwell may adjourn his special committee, until after Christmas at any rate. By that time the voice of war will have given the verdict; by that time the Chassepot, the Zundnadelgewehr, the shrapnel, and the volley-gun will each be credited with a ghastly account, and we shall know which engine destroys human life in the shortest time, the easiest manner, and at the least possible expense. —*Globe.*

INTERNATIONAL COMMUNICATION.—Mr. Bessemer supplies the following description of his invention for improving steam communication by the construction of a suspended chamber. He says:

"The experimental vessel is of only 153 tons measurement, and although much too small to attain the best results, is, nevertheless, quite large enough to make the Channel passage, and prove beyond question the practicability, or otherwise, of the mechanical principle involved. Not the least of the advantages which the new system of ocean transit offers is the shortness of the time and the small amount of capital required to put it into operation at every seaport in the kingdom. For instance, two steamers, fitted with means for the most luxurious accommodation of passengers, in vessels of great size, and having sufficient engine power to cross the Channel in 60 to 65 min., and fully adequate to carry the entire passenger traffic, could be put on the station within eight or nine months from the date of order, at a cost not exceeding £130,000. The commercial advantages of such a system, as compared with those proposals which would require some £8,000,000 or £10,000,000 sterling, and several years to execute, will be readily appreciated by the public, the more so as my system will be subjected to the test of actual trial before a shilling need be expended by the public upon it. The proposed new system does not contemplate the employment of ships that shall be motionless except in the direction of their course, for the waves would strike on such a vessel as on a rock, and dash themselves over her as they sometimes leap the Eddystone. It does not attempt to arrive at the end desired simply by construction of ships or rafts of vast size, for it is well known that the largest ships that have ever been built roll frightfully in the Channel in bad weather; nor is it by any new and untried external form of the vessel, involving new problems in navigation; on the contrary, my system in no way whatever interferes with the external form or with the sailing qualities and safety of the vessel, the whole difference being in the internal arrangements of the ship, and is based on the well-known law that all bodies which revolve or roll, in so doing move about a centre where there is no motion, and all beams that vibrate move also about a centre, from which point the distance moved through by any part of the beam is as the distance from this central point. Now, therefore, if we make the centres about which the vessel pitches and rolls coincident with the axes on which the saloon is suspended by suitable mechanism, and provided with a heavy counterbalance weight beneath the centre of gravity, the tendency of this weight will be at all

times to keep the saloon poised on the centre of the vessel's motion, and therefore free from pitching or rolling, its floor remaining always quiet and horizontal, while the vessel itself may be pitching and rolling about the centre of suspension. The most convenient form for such a saloon is circular, surmounted by a large dome, lighted at the top with glass. It is proposed to make this circular saloon of 50 ft. in diameter, and 28 ft. in height internally, having a gallery extending entirely around its interior at about 9 ft. from the floor. A continuous couch around this gallery would accommodate 60 persons, while about 70 others would find a similar accommodation below, independently of the large space afforded by the floor of the saloon. This large and lofty apartment, although much smaller, would present somewhat the general appearance of the new reading room at the British Museum. It would be supplied with plenty of cool, fresh air, from below, which would pass off through the glass louvres in the dome; the saloon would be entirely separated from the rest of the vessel by water-tight bulkheads, thus cutting off all unpleasant smells from the engines and boilers. The suspension is so arranged that the vibration of the engines and propeller cannot be transmitted to the saloon, which is also relieved from the constant thud of the waves striking against the sides of the vessel, because there is no contact between the ship's sides and the walls of the saloon. Suitable ante-rooms leading from the saloon are also provided for invalids, etc. The general plan also embraces the construction of raised deck platforms, so arranged that those who prefer the open air may have beneath them a steady platform free from the rolling and pitching motion of the vessel.

"From the cursory view here given of the mode in which I prose to secure at all times a perfectly steady platform on board ship, the scientific reader will doubtless see many grave difficulties. He will probably ask: How do you propose that passengers shall pass from the reeling deck backward and forward at all times into your quiet immovable saloon; how can you prevent a pendulous motion of the saloon from being set up by the variation in position of the centre, which will occur unless your vessel rolls and pitches at all times actually on a point coincident with the point where you have established your centre of suspension? How can you prevent the saloon from being put in motion by people moving in it from side to side? My reply to these anticipated queries is simply that each of them and many others besides have been presented to my mind in full force during the elaboration of my plans, and each has been so fully met and provided for as to offer not the slightest obstacle to that success which I believe my little ship, the Enterprise, will fully establish when put to sea, until which time I must beg the critic to suspend his judgment."—*The Railway News.*

THE CHASSEPOT AND THE NEEDLE GUN.—Some account is published in the "Birmingham Gazette" of Monday of the two weapons which are in the hands of the belligerents on the Continent. The "Zundnadelgewehr" or needle-gun of the Prussian service, to which the victories of the Prussian arms in 1866 have been attributed, appears to have been originally patented in England as a muzzle-loader in 1831, by a Mr. Moser, of Kennington. The invention came before its time. Its cold reception in England drove the patentee to seek foreign patronage for his novelty, and Prussia was lucky enough to appreciate and to adopt the new weapon. Dreysa, a gunmaker of Sommaler, applied the breech-loading principle to Moser's patent, and thus amended, the arm ten years later was in 1848 introduced into the Prussian service. The principle, briefly stated, is the driving of a pointed piston or "needle," by the action of a spiral spring (such as is used in the manufacture of children's toy guns) into a small case of fulminate, contained in and situated between the powder and the bullet of a single cartridge. In the action of opening the breech, the spiral spring is set by the trigger, and thus the trigger, when pulled, releases into operation the spiral spring, which, in its turn, forces the needle into the cartridge, and fires the piece. Upon this oldest form of the Prussian needle-gun improvements have been made, the chief effects of which have been a reduction of the mechanism of the needle of 1848, and a general lightening of the entire piece. None of these alterations, however, have touched those two apparent evils in the whole form of this arm which militated against its adoption by England in 1850. These are the positions of the fulminate in the interior of the cartridge and the looseness of mechanism, involving possibility of the escape of gas round the needle and at the base of the plunger. To these two particular points France mainly devoted herself in seeking a superior needle rifle to that of Prussia. In the Chassepot such an improved arm has been found. A triple wad of vulcanized india-rubber placed round the axis of its plunger, and with a steel plate a cushion to receive the force of the rebound, is intended to render the breech gas-tight, but has been found in practice only partially adapted to that object. An ingenious arrangement of notches on the outer girder of iron, before described, enables the gun to be placed at half-cock. The needle is lighter and smaller than in the Prussian gun, and, above all, the cartridge contains its fulminate at the base of the powder, instead of at the base of the bullet. A vacuum left when the gun is charged, between the base of the cartridge and the front of the plunger, is intended to effect the combustion and removal of any portion of the cartridge-case that may remain after firing. As compared with the Prussian gun, this weapon possesses, besides the specific improvements mentioned, other advantages of superior manufacture and finish. Its cartridge, besides admitting the altogether different principle of firing contains a larger charge of powder than the Prussian cartridge, with a smaller bullet, which leaves a manifest advantage in carrying to the French weapon; while the fact that the Prussian bullet is purposely made so small as not to touch the barrel in its passage, while the French bullet is of the ordinary size to fit the rifle barrel, would point to the conclusion that the Prussian marksman is at a disadvantage over the Frenchman in respect to his aim. The number of times of firing per minute is about the same in both cases. The cost of the French weapon considerably exceeds that of the Prussian, and the Chassepot is, in addition, a more difficult gun to make. To all the comparative information which has been published about the French and Prussian guns must be added the following from the "Journal du Peuple":—"At 500 metres the Prussian weapon gives only negative results, while at 1,000 the Chassepot, in the hands of good marksmen, hits the target with great force. We

call attention to this point, for in the war of large bodies of sharpshooters (the only system which we ought to adopt), an arm which is not reliable over 500 metres cannot reach the reserves of the first front, which escapes the effect of the enemy's fire. The drawbacks of large bullets have been noticed, the principal being this, that with needle-guns, the firing is rapid, and, therefore, a great amount of powder is burnt; consequently, the cartridge-box must be well stored. Now, there is in the weight of ammunition allotted to a foot soldier a total which cannot be exceeded, namely, 10 lbs. What will happen? With that weight of cartridges, the Frenchman will have twice as many shots to fire as the Prussian. Nothing is more difficult than to replace during fire the ammunition by a fresh distribution. Thus, the retreat of a division may depend on its finding itself in face of an enemy which has still twenty or thirty cartridges a head to fire. It will be seen that the winning of a battle may depend on the projectile adopted."—*Globe.*

An extremely satisfactory result, as far as the navy is concerned, was lately obtained at Shoeburyness. A target representing a portion of the deck of an iron-clad ship, protected by 1-in. iron plates, was fired at by the 9-in. muzzle-loading rifled gun, the projectile being Palliser shell, the charge the full battering one of 43 lbs., and the distance 100 yards. The target was so arranged that the projectile struck at an angle of about 8 deg. from the horizontal, so as to represent the angle of incidence of a shot fired direct at about 2,000 yards, or that of a projectile fired at 100 yards from a higher level; such, for instance, as that of the "Monarch's" battery as compared with the "Captain's." It was found that at this angle the projectile did not enter the ship, but, after ploughing up the woodwork of the deck, ricochetted off it, and went away screaming and whistling up into the air until lost from sight. One of the disadvantages urged against a low freeboard is thus disposed of as far as 9-in. guns are concerned. The "Monarch," however, is armed with 12-in. guns, and it would be interesting to ascertain whether the above results would hold good in the case of the larger calibre. It seems desirable also to ascertain the actual angle at which a projectile fired horizontally will penetrate a ship's deck protected with as much iron as is admissible in its construction. Ships' decks may often be subjected to a plunging fire from elevated batteries, such as those on Straddan Heights or Gibraltar.

ENGINEERING STRUCTURES.

Elevated Railroad.—The West-side Elevated Railroad, extending from the Battery, at its lower terminus, to 30th street, along the line of Greenwich street and Ninth avenue, has been opened to business long enough to enable the public to arrive at very correct ideas concerning it; and, as far as we have been able to learn from inquiry and observation, the voice of public opinion has long since pronounced it a failure. So far, it has secured considerable patronage during the semi-occasional intervals between break-downs and accidents in which it has been possible to run cars; but there is nothing to indicate that it can ever be made a financial success, since but few of those who pass over it once are well enough satisfied with their experiences as to care to repeat them. Considered simply as an experiment in engineering, there is nothing in the structure or the operation of the propelling machinery to enable an impartial and disinterested critic to pronounce it a success; since it is constructed with but little apparent regard for scientific or mechanical principles; and although it has been found possible to dispatch cars back and forth over the track, the road, as far as completed, does not realize in any sense the expectations of those who have furnished the money expended upon its construction. The method of propelling the cars by means of a succession of endless wire cables is not a success in any respect, as the motion is uneven and disagreeable, and the gradual loss of impetus in passing over the bridges between the sections, necessitates a succession of sudden and unexpected jerks as the tracks attached to the cables come in contact with the spring affixed to the under part of the car. The worst feature of the road, however, is the weakness of the structure, sustained by single posts, and possessing no side braces or supports to overcome the lateral motion of the heavy cars balanced upon the spreading arms that hold the tracks. These defects should have been discovered before 100 ft. of the road had been built, if not sooner, and we are surprised that the plan upon which it is built was not long since abandoned as impracticable. From personal experience, we are forced to the conclusion that it is neither safe, rapid, nor pleasant; and when it shall have ceased to be a novelty, there is but little reason to believe that it will command more than a very limited patronage. But even if it were a success in all respects, it could not carry passengers enough to make the enterprise a profitable one, since the traffic over the single track is necessarily limited. We regret our inability to speak more favorably of the road, but a due regard for candor compels us to say that it does not meet, in any essential particular, the expectations or requirements of the travelling public. It can not be denied that we need better and more rapid facilities of transit within the limits of the city than are afforded by the surface roads and omnibus lines, but something different from the elevated railroad is needed; and, for the sake of those who may be induced to furnish the capital needed to complete the work, we hope the company will not carry out their original intention of extending the road beyond 30th street.—*Iron Age.*

Amsterdam Ship Canal.—Next to the Suez Canal in magnitude is the Amsterdam Ship Canal, which has been in progress about 5 years, and is expected to be completed in 1876. The canal is being formed through two lakes, both of which are shallow, first by making embankments on each side of the line of canal, and then by dredging out the material between to the requisite dimensions. A deep excavation is being rapidly formed from the lakes to the North Sea, through the sand-hills, and outside this piers built of large concrete blocks are in progress, which will extend about a mile into the sea, and enclose within them an area of about 200 acres, which will be dredged to a depth of 24 ft. below low water. The canal will also have 3 locks at the North Sea entrance, a little eastward of the harbor. The canal will have a width at the bottom of 88 ft., which is 16 ft.

wider than the Suez Canal; a width at the top of 195 ft.; and a depth of 23 ft. The locks will be wide enough to admit ships of the largest class.

NEW BOOKS.

DES MACHINES A VAPEUR; Leçons faites en 1869-70 a l'ecole imperiale des ponts et chausées par F. Jacqmin, Ingenieur-en-chef des Ponts et Chaussées, etc., etc. Paris: Garnier Freres. For sale by Van Nostrand.

This work is in two octavo volumes, numbering together 950 pages, and presents a complete discussion of the theory and practice of steam engineering.

Beginning with the theories of heat, the author reviews the labors of Rumford, Joule, Hirn, Mayer and others. Then are presented the laws of vaporization, of specific and latent heat, of the tranformation of heat into force and force into heat, of dilatation of solids, liquids and gases.

In treating of the engine the same completeness is observed. Boilers are first classified, and each class described. Then the conducting pipe, the cylinder, condenser of every kind successfully employed, are each described in proper order, but do not occupy the proportionate space in the book that would be afforded by an English writer.

The metals used in construction of engines receive their full share of attention.

The discussion of the methods of transmission of the force of steam is quite a thorough treatise on mechanism.

The description of all portions of a railway equipment is surprisingly minute.

One defect in the work, which is inexplicable to an English student, is the absence of graphic illustration. Throughout nearly 1,000 pages of description of machines, tools, and mechanical device there is not a single diagram.

PRACTICAL MINING FULLY AND FAMILIARLY DESCRIBED. By GEORGE RICKARD. London: Effingham Wilson, 1869. For sale by Van Nostrand.

Within a very narrow compass—for Mr. Rickard's treatise does not exceed the limits of a moderately-sized pamphlet—the author has compressed a great amount of information, which might have been easily distended into a large volume. Indeed, considering the clear and practical manner in which this little book is written, one regrets that the author has not done more. In his opening chapter Mr. Rickard sketches briefly the geology of Cornwall and Devon, for it should be mentioned, that as evidently the author's mining experience has been derived from the practice those two countries afforded, so the contents of "Practical Mining" refer entirely to those ore-bearing districts. But if the various formations are briefly mentioned, their areas, directions, and limits are all carefully described, and the boundaries are identified by the towns and villages which skirt them. This chapter concludes with a notice of special formations, the directions and peculiarities of the metallic lodes, and the phenomena which disturb and break up the veins of ore from their original position.

The grauwake, or clay slate, which surrounds more or less the granite formations, both of Cornwall and Devon, is very productive of minerals, as well as the junction between the two formations; and rings of mines are formed on these lines of junction, some wholly in granite, some wholly in the grauwake, and some in both. The minerals produced from these mines are generally copper and tin. Although the lead mines are sufficiently near the border of the granite to be close to the ring of mines, their continuity is not sufficient to give them the same circuitous route. Lead ore, indeed, is for the most part scattered over Cornwall and Devon, whilst the copper and tin mines are also partially scattered in irregular positions throughout both counties. After some briefly-considered details relating to the preliminary proceedings of speculators breaking new ground, Mr. Rickard proceeds to consider the necessities which ought to rule in fresh work, and to point out the many failures and the great losses which have attended a want of care in the outset; here again the reader regrets that nothing but a recapitulation of the needful considerations is given; and that the author has not dwelt upon them in detail. The same fault, indeed, runs through the whole book, but in every page the author proves his familiarity with the subject. Exception must also be made to the want of method shown in dealing with the theme, which gives an idea of incompleteness, and causes trouble to the reader. These drawbacks, however, manifestly arose either from a want of care on the part of the author, or a lack of experience in arranging his information; faults to be amended without difficulty, and which we hope will be amended in a future and more extended edition.

ON THE STRENGTH OF BEAMS, COLUMNS, AND ARCHES. By B. BAKER, Assoc. Inst. C. E. London: E. and F. N. Spon, 1870. For sale by Van Nostrand.

The subject-matter of this little volume is of great importance to civil engineers. All structures resolve themselves ultimately into beams, columns, and arches, of some kind. It is therefore of great importance that the engineer should be familiar with the mode of ascertaining their strength or their resistance. We approve, in the main, of Mr. Baker's endeavor to dispense with high mathematics by substituting geometrical solutions for ordinary problems, because, unfortunately, mathematics is not the strong side of English engineers, although England has produced the greatest of mathematicians. But the author seems to labor under serious misapprehensions. He proposes his geometrical solutions, because he thinks that the use of mathematics "involves an unjustifiable waste of time, with the great contingent disadvantage that it checks the growth of sound judgment in the engineer, by giving a fictitious appearance of accuracy to his results which are not susceptible of exact deduction." This is a grievous error. The spirit of mathematics is the expression of most acute and refined reasoning; and now can the practice of intellectual reasoning check the growth of sound judgment in the engineer? The fictitious appearance of accuracy above mentioned is altogether beside the question, because it is optional; but not so the correctness of our reasoning and arguments. The author makes the above statement in his preface, and we find, unfortunately, that throughout the volume the spirit of mathematics is sadly offended. Let us take for example the author's mode of calculating the

strength of beams. He shows us how the strength of a beam may be found geometrically, and derives the formulæ for rectangular and other beams, assuming the neutral axis of the beam to pass through the centre of gravity of the sectional area of the beam.

How to Use the Barometer. By the Rev. R. Tyas, M. A., LL.D. London: Benrose, 1870. For sale by Van Nostrand.

We have often called attention to the great importance of a generally-known and uniform method of making even the simplest meteorological observations; for we are convinced that, till something of this sort is done, the weather statistics collected by the amateur meteorologist cannot be regarded as reliable. Now, the present volume, though it is unpretending enough, and can hardly be styled a scientific treatise, is nevertheless a handy and useful little work, well calculated, we should think, to meet the want we have referred to. It is a short and clear account of the objects of meteorological study, of the form and construction of the principal meteorological instruments, and of the methods of employing these instruments so as to obtain correct records of the condition of the atmosphere, temperature, and so forth. It is published annually, and so, while useful as a handbook to the weather-glass, it is doubly so in a practical sense, by the fact that it contains numbers of blank tables which the young meteorologist can fill up for himself, and thus become thoroughly familiar with the mode of preparing returns. There are a good many illustrations, and one of them—that of the author's thermometer-stand—may offer a hint to many who are ignorant of the fact that records of temperature are useless unless the conditions under which the thermometer should be placed are fully observed. The only part of the book we object to is the introduction, which contains some "fine writing" of a very clumsy character. Practical men should avoid that kind of thing.—*Scientific Opinion.*

The Manual of Colors and Dye Wares. By J. W. Slater. London: Lockwood & Co. Sold by Van Nostrand.

The subject of this alphabetically-arranged manual is to furnish, in brief space, an account of the chemical products and natural wares used in dyeing, printing, and accessory arts—their properties, their applications, the means of ascertaining their respective values, and of detecting the impurities which may be present. Information of this kind seems to be needed both by makers, dealers, and consumers. The author relies more upon strictly chemical methods, as distinguished from rule-of-thumb procedures. He believes there are means of forging those outward features of color, touch, taste, etc., upon which so many rely. It has not been any part of the plan of the book to give receipts either for the manufacture of colors and mordants, or for their applications in dyeing and printing, as there are already books which profess to do so. Few persons, however, are so generous as to reveal to the world the best and newest processes in their possession, as the author remarks, and he himself is no exception to the rule.

In the preface the author alludes to an alleged discovery, which is to rival the tar colors in brilliance and purity.—*The Builder.*

Peat Fuel: How to Make it and How to Use it. By T. H. Leavitt. Boston: Lea & Shephard. Sold by Van Nostrand.

This neat little volume contains practical information of considerable value to those who want cheap fuel in regions where coal is scarce and peat easy to obtain. Hitherto our forests have supplied us so abundantly with wood, in localities remote from coal, that we have never paid much attention to the utilization of a fuel which is doubtless capable of supplying the place of either coal or wood for many purposes. The extensive use of peat in portions of Europe, particularly in parts of Ireland, where "turf" is used almost to the exclusion of every other kind of fuel, is too well known to need further comment. In many instances the peat, merely cut and dried, is used directly as fuel, but there is no doubt that in many cases a more elaborate treatment, as recommended by Mr. Leavitt, will yield favorable economical results. An Irish doctor, writing in 1685, says: "Turf charred, I reckon the sweetest and wholesomest fire that can be; fitter for a chamber and for consumptive people than either wood, stone coal, or charcoal."—*Engineering and Mining Journal.*

The Disposal of Town Sewage. By R. W. P. Birch. A Paper read before the Students of the Institution of Civil Engineers. London: E. & F. N. Spon. For sale by Van Nostrand.

We have before us the reprint of a paper recently addressed to the students of the Institution of Civil Engineers by one of their number; and to the author of which a Miller prize was awarded. The treatise in question is not remarkable as a literary effort, nor for any close investigation of the subject on which it treats, and it is blemished by one or two unfortunate mistakes; but despite these things Mr. Birch's paper is a production worthy of consideration and of study—first, on account of the information it contains and the hints it suggests; and, second, because it may fairly be considered a representative paper of the student class of the Institution.

The author considers his subject under two heads—the disposal of sewage by water carriage, and its direct application for irrigation, and the treatment of it by mechanical or chemical means for the separation of the sewage matter from the water in which it is contained, and the consequent prevention of pollution of rivers into which the water is discharged. Pointing out the drawbacks of the various methods of irrigation by means of porous pipes laid deep within the ground, of hose and jet distribution, and of irrigation by submersion, and the advantages of the remaining plan of surface channels, the author proceeds to illustrate the progress and success of sewage irrigation by the statistics gained by experience in the places where it has been tried. Aldershot, Banbury, Bedford, Croydon, Norwood, Rugby, Warwick, and Worthing are the leading examples of sewage farms, where more or less of success has attended the introduction of this system, so carefully worked out by Mr. Baldwin Latham at Croydon. Turning to the consideration of the mechanical purification of sewage, the author gives an account of the filter beds at Ealing, where 400,000 gals. are passed daily through the settling tanks. There are two of these tanks employed, 64 ft. long by 10 ft. wide by 8 ft. deep each, separated into 4 compartments by timber partitions, which allow

the passage of the water while arresting solid deposit. Flowing to the end of the tank, the sewage first encounters a gravel filter, 12 ft. long and 10 ft. wide. Between these and the filter beds are placed beds of charcoal, retained by iron gratings, through which the sewage passes; flowing up into the first set of filters, formed of burnt clay ballast, thence over a weir into the second filter beds through 2 ft. of ballast. In this way there is a constant flow through 7 ft. 4 in. of purifying material, and the residue mixed with the ashes collected from house to house amounts to 1,000 tons a year, which sells readily.

With regard to the chemical methods of purification, the author describes the first and highly successful lime process of Higgs and Wickstead, dating so far back as 1846 and 1851, and arrives at the conclusion, borne out by experience, that this plan, if properly carried out, although costly, is yet an effectual means of purification.

Of all the chemical and other systems, however, recommended by the author, the one known as the A B C process is most favorably thought of by the author, and it is this portion of his paper we had in mind when we complained of its shortcomings. For while it is evident that the essay on "The Sewage Question" leads up to Messrs. Sillar & Wigner's process, which is dwelt upon at considerable length, and while the author is "confident that their plan is a profitable and inoffensive one for extracting valuable manure from sewage," we find in a foot note that "circumstances have come to light in connection with the carrying out of the A B C process at Leamington, that have caused the author to entirely change his opinion as to its efficiency, both in a sanitary and commercial point of view." Although this latter conviction is confirmed by the Rivers Pollution Commissioners, who have recently condemned the A B C process "as expensive in its application and unsatisfactory in its results," it is nevertheless unfortunate that the opinion so confidently expressed in May, should be contradicted two months after, and that only by mere assertion. Such a fault as this, however, in a really useful essay, is very pardonable, and is an illustration of what we just now mentioned as a fault of the student's papers, where conclusions arrived at in a hurry, and placed on record, have sometimes to be retracted afterwards.—*Engineering*

ON THE APPLICATION OF CAST AND WROUGHT IRON TO BUILDING PURPOSES. By Sir WILLIAM FAIRBAIRN, Bart., C. E., F. R. S., etc. 4th edition, with additions. London: Longmans, Green & Co. 1870. For sale by Van Nostrand.

In this new edition of a standard work there is a considerable amount of new matter, including a careful revision of the third edition, and an enlargement of the work. It now contains an experimental inquiry into the durability of wrought-iron beams and girders, the influence of the force of impact, and a long series of changes of variable loads affecting their ultimate powers of resistance. These researches are of high importance, when considered as a safeguard to the amount of load or strain to which beams or girders are usually subjected. In this edition there will also be found experimental researches on the properties of steel and homogeneous iron, to which the architect and engineer may safely refer; and as these investigations have reference to a material which may ultimately take the place of iron where security and strength are required, the author states that he has no hesitation in submitting it to the consideration of his readers. In an appendix is given a series of experiments on timber trussed beams, showing the comparative value between wood and iron in that form. It shows the principle on which wood and iron trussed beams should be constructed.

PROTOPLASM, OR LIFE, MATTER AND MIND. By LIONEL S. BEALE, M. B., F. R. S. London: J. Churchill & Sons. For sale by Van Nostrand.

This is by far the most thorough and scientific examination of the "physical basis" question we have yet seen. The spirit and intention of the author are fully shown in the following extract from the preface:

"My views upon the nature of vital actions are at variance with the doctrines now generally entertained and taught. I am therefore very desirous that those interested in the subject should have in small compass the general statement of the facts as they appear to me. It is to be regretted that upon the most elementary propositions connected with this inquiry, opinions are sadly conflicting, and many of the facts and statements upon which they are based and which are urged in their behalf are quite irreconcilable with one another. It is therefore very difficult for readers to form an impartial judgment. But I trust it is not too much to ask that the observations which have led me to the views I entertain, should be brought under the notice of those who have not yet subscribed to the doctrine that living things are mere machines built up by physical forces only, and made to act by force alone.

"Intense energy and activity are displayed by certain members of the new school in giving publicity to their views; they press them in many different forms, and endeavor to enforce the acceptance of the physical doctrine of life, and much besides which it is supposed to include, with all the proverbial ardor and authority of prophets. All this renders it very desirable that every one who is engaged in actually investigating a matter of such deep general interest should do his utmost to make the conclusions at which he arrives intelligible, without affectation of learning, without mystery, and without in any way exaggerating the importance of what he may have to communicate. For the public may reasonably desire some calm statement of proved facts in a matter of such importance. It should be the writer's endeavor to tell his story simply, so that those who wish may learn, and to take pains to make the facts as clear to other minds as they appear to his own, without trying to amaze by calling in the aid of startling similes and striking illustrations, which but too often divert the attention from the real matter under consideration, and are calculated to distract the mind and prejudice the judgment."

SPECTRUM ANALYSIS: SIX LECTURES DELIVERED IN 1868, BEFORE THE SOCIETY OF APOTHECARIES OF LONDON. By HENRY E. ROSCOE, B. A., Ph. D., F. R. S. Second edition. London: McMillan & Co. For sale by Van Nostrand.

This new edition of the elegant volume of last year contains many important additions. The ac-

tive workers in this department of science have done much in the last twelve months to extend our knowledge, especially of the physics of the sun. The whole of that portion of the book relating to celestial chemistry has been rewritten. Late papers to learned societies appear as new appendices, and the work is further enriched by several new illustrations.

NOTES OF A COURSE OF NINE LECTURES ON LIGHT, DELIVERED AT THE ROYAL INSTITUTION OF GREAT BRITAIN. By JOHN TYNDALL, LL. D., F. R. S. London: Longmans, Green & Co. For sale by Van Nostrand.

These are brief notes of the author's lectures, but contain a complete exposition of the science of Optics. They will prove invaluable to the teacher who desires the most concise statement of our present knowledge of this science, and notwithstanding the brevity of treatment the general scientific reader may find here a satisfactory elucidation of those rarer phenomena of diffraction and polarization which the more ponderous works frequently omit to discuss, or quite as often obscure by their use of intricate formulas.

MISCELLANEOUS.

A PNEUMATIC TELEGRAPH.—An Italian gentleman, Signor Guattari, exhibited at work, at 66 Gloucester-street, Warwick-square, Pimlico, a system of telegraphing, whereby he worked a Morse instrument at the end of a long pipe by means of compressed air. The pipe, which was coiled round a drum, was of vulcanized india-rubber; it was about ¼ in. in internal diameter, and was stated to be about 500 metres in length. The rest of the apparatus consisted of a copper chamber containing compressed air, an air pump for charging the chamber, and a "key" or commutator, to let puffs of air traverse the pipe to work the Morse instrument at the end thereof. With these appliances the inventor sent messages, which were very clearly printed, by the Morse, when the rate of serving was about half that of the ordinary rate of electrical signalling. With the exception of the air-pump, the first cost of the apparatus is slight, since messages may be sent by abolishing the "key" altogether, and timing the impulses by simply pinching the india-rubber pipe with the figures. For short distances, where a speaking tube can be used, the speaking tube is the cheapest and most expeditious instrument, and against it Signor Guattari's apparatus stands no chance. The greater the distance the more will the elasticity of the air, and its friction against the sides of the pipe, make the air impulses run into each other, and diminish the speed of signalling, and no very long line can possibly be worked by the system to commercial advantage. It may, however, do for distances rather too great for a speaking tube to be applicable. In such cases, its advantage or disadvantage, as compared with a Morse telegraph worked by electricity, is a question of cost of air-pump and tubes, as compared with cost of batteries and wires. The inventor told us that the pressure he used while signalling before us was only 1¼ atmospheres; if, by the aid of a head of water, or in any other way he can get the pressure, thereby abolishing the rotary air-pump and diminishing the expense, his plan would be able to compete better with other systems. He has succeeded in making his apparatus work well, and the question of its adoption to signal messages to stations a little further than can be reached by speaking tubes, is simply one of cost. The inventor says that "he has already been rewarded with the gold medal of the Italian Royal Society of Arts; obtained the support and recommendation of Prince Humbert; and the Italian Government has adopted the system, and given orders for its use on board all the men-of-war comprising the Italian navy."—*Engineer.*

THE BRITISH AUSTRALIAN TELEGRAPH.—The British Australian Telegraph Company state that they have received information to the effect that the South Australian Government will give every facility for the landing of their cable at Port Darwin, and that the Government undertake to introduce a measure immediately after the new Parliament meets, for providing by means of a loan for the construction at once of a line of telegraph from Port Augusta to Port Darwin. To remove all cause of jealousy, as well as to provide an alternative line, Queensland would be invited to connect at some convenient point. The company would then have a connection with two independent routes, which would make them secure from interruption. The South Australian Government will not only undertake the construction, but the maintenance of the land line.

A PARLIAMENTARY paper of London gives copies of report and correspondence as to the reward to inventors proposed in the army estimates for the current financial year. These rewards are as follows: A grant of £100 to Mr. C. F. Guthrie, for an ingenious and efficient rolling bridge, applicable to defensive works. It is proposed to pay the sum of £500 to Mr. S. A. Goddard, for his improvements in breech-loading cannon. In the case of Mr. Parsons, who alleged that the Palliser gun was really invented by him, the matter has been referred to Mr. Gregory, the President of the Institute of Civil Engineers. The Treasury has sanctioned a grant of £500 to Commander Colomb, as a final reward, on account of his signals for naval and military use. The Treasury has also resolved to ask Parliament for £1,700 to be granted to the representatives of the late Jacob Snider, for his invention of breech-loading rifles.

AN improvement has been made in the manufacture of carbonate of lead, by the action of the soluble acid carbonates of the alkali on litharge, hydrated oxides of lead, or insoluble basic salts of lead, with an equivalent of bicarbonate of soda, together with sufficient water to form a stiffish paste. This mixture is ground in a suitable mill, small quantities of water being from time to time added as may be found requisite, until the change of the lead bodies into carbonates is complete. The paste is now well washed with water, and the supernatant liquid which contains the carbonate of soda is separated from the white lead by filtration, and boiled down to dryness, and disposed of as soda-ash; or it may be crystallized, or may be again converted into bicarbonate of soda by treatment with carbonic acid, and used to convert further quantities of lead oxides or insoluble basic salts of lead into carbonates.